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IUFRO World Series Vol. 20-II Keep Asia Green Volume II "Northeast Asia"

IUFRO World Series Volume 20-II

Keep Asia Green

Volume II "Northeast Asia"

Edited by Don Koo Lee

AKECOP

Yuhan-Kimberly

International Union of Forest Research Organizations
Union Internationale des Instituts de Recherches Forestières
Internationaler Verband Forstlicher Forschungsanstalten
Unión Internacional de Organizaciones de Investigación Forestal

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ISSN 3-901347-55-0

ISBN 978-3-901347-76-4

IUFRO, Vienna 2007

Recommended catalogue entry:
Keep Asia Green Volume II "Northeast Asia", 2007.
Don Koo Lee (editor)
IUFRO World Series Volume 20-II. Vienna, p. 170

ISSN 3-901347-55-0
ISBN 978-3-901347-76-4

Cover photos:
1. Birch grove, Russia
2. Terelj National Park, Mongolia
3. Forest land degradation in Mongolia

Photos by Victor Teplyakov, Alexander Buck, J. Tsogtbaatar

Published by:
IUFRO Headquarters, Vienna, Austria, 2007

Available from:
IUFRO Headquarters
Secretariat
c/o Mariabrunn (BFW)
Hauptstrasse 7
1140 Vienna
Austria

Tel.: +43-1-8770151-0
Fax: +43-1-8770151-50

E-mail: office@iufro.org
Web site: www.iufro.org

Price:
EUR 20.-
plus mailing costs

Printed by: Okchon, Seoul 121-801, Republic of Korea

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FOREWORD

The forests of Northeast Asia cover a large area and face a multitude of social and environmental challenges. Widespread deforestation and forest degradation have resulted in the mass alteration of forests. Overgrazing and desertification in Mongolia, an absence of efficient methods to prevent and extinguish forest fires in Russia, widespread wind erosion and desertification in China, forests ownership issues in Japan, overexploitation of forests for economic gain and urbanization in DPR Korea, and industrialization in the Republic of Korea are some of the past and present issues plaguing the region. Among these, one of the most prominent areas of concern is desertification. The desiccation of land - whether from overgrazing, conversion, deforestation, or other - results in 'yellow dust storms' whose effects can be felt throughout Northeast Asia.

To some degree, the governments of these nations have made strides to offset the negative impacts of deforestation by implementing reforestation and rehabilitation initiatives. Some of the environmental initiatives include pest mitigation; erosion control through terracing, drainage canals, sodding, and afforestation; fire suppression and burned area management; shelterbelt construction; reforestation of clearcuts and glades; and changes in forest harvesting patterns and mechanisms, among others. The introduction of social initiatives include the implementation of logging quotas; forest tax and fee systems; the reevaluation of forest ownership and tenure systems; and the creation of educational and training programs for the sustainable management of forests. The most significant recent change in forest management has been the shift from "industrial" forest management to "ecosystem" forest management. Simply by examining the state of Northeast Asia's forests it is easy to see that a great deal more effort and investment is required to rehabilitate the region's forests.

The continuance of the "Keep Asia Green" book series indicates a concerted effort to work towards the rehabilitation of the region's devastated forests. It aims to understand national capacities in terms of forest rehabilitation and existing education programs, and to analyze the need for further strengthening of forest landscape restoration efforts in each country, as well as each region, in Asia. This project was made possible through the initiative of the ASEAN-Korea Environmental Cooperation Project (AKECOP) in cooperation with the International Union of Forest Research Organizations' Special Programme for Developing Countries (IUFRO-SPDC). I am inspired by the effort and commitment shown to this project and am honored to be a part of what will be a great contribution to the Northeast Asia region.

The second volume of the book focuses on the six countries encompassed in the Northeast Asia region; namely the People's Republic of China, Japan, DPR Korea, Republic of Korea, Mongolia, and the Russian Federation. It compiles information on the historical perspectives of land use change, the present state of forest degradation, and addresses forest rehabilitation needs, including major lessons learned from the countries' case studies. Additionally, recommendations are made for future actions to further enhance the approaches to forest rehabilitation, so that investments in trees and forests can achieve an even greater impact, thus providing enhanced environmental services and economic benefits for the well-being of present and future generations.

This book is the first of its kind in Northeast Asia. It is an important contributor to the objectives of forest restoration and essential reading material for practitioners and decision-makers involved in forest restoration.

Finally, please allow me to express my sincerest gratitude to AKECOP and its staff for initiating this noble deed; to all forest scientists, including lead authors in the different countries of the Northeast Asia region, for sharing the necessary information to come up with this book; to Dr. Michael Kleine (Coordinator of IUFRO-SPDC) for his dedicated effort and great contribution to this project; and to Yuhan-

Kimberly, Ltd. for its substantial financial support to this publication and endeavor. The assistance of Mag. Eva Maria Schimpf and Mag. Margareta Khorchidi of IUFRO-SPDC in language editing and lay-out of the book is much appreciated. To all of you, thank you and let us continue the pursuit of keeping Asia green.

Prof. Don Koo Lee
IUFRO President

Afforestation and Ecological Restoration in Northeast Asia

A Synthesis

by Michael Kleine and Don K. Lee

1. Introduction

Over the last century, land use in the Northeast Asian region has changed significantly. This is also true for the management and conservation of the region's vast forest resources. Driven by wars, population growth and economic development, forests have on one hand been on the decline, but on the other hand were restored and rehabilitated at a pace and scale unimaginable in other parts of the world.

The second volume of the Keep Asia Green Book Series covers six countries in Northeast Asia, namely the Peoples' Republic of China, Japan, the Democratic People's Republic of Korea (DPRK), the Republic of Korea, Mongolia and the Russian Federation. These countries extend over vast areas of the Asian continent ranging from Siberia and the Russian Far East in the north with its boreal climate, to the tropical and subtropical islands of Hainan (China) and warm-temperate climate of Jeju (Republic of Korea) in the south; from the temperate climate of Japan in the east to the deserts, steppe ecosystems and high mountain ranges of Mongolia and China in the west. The area is known for its diverse array of topographies and climates, allowing for the existence of a wide variety of forest ecosystems and landscapes.

This book provides insights into the historical perspectives of forest land use changes in Northeast Asia and explains – separately for each country – the efforts undertaken and results obtained in the rehabilitation of forest ecosystems, including the expansion of forest cover through reforestation and afforestation. Approaches and methods of forest rehabilitation are presented along with the political, legal and institutional requirements for their successful implementation. In addition, past and current systems of forest research and education, with special reference to forest rehabilitation, are discussed in the various countries. Each country paper concludes with recommendations for future action to further the course of forest rehabilitation under rapidly changing socio-economic conditions.

This synthesis paper summarises the main issues addressed in this book and may serve readers as a guide to additional country-specific information on forest rehabilitation in Northeast Asia as described in the individual book sections.

2. Historical Perspectives of Forest Land Use Change in Northeast Asia

Today, the extent of forest cover in Northeast Asia varies considerably between countries and subregions. This is not only due to natural conditions shaped by climate, elevation and topography, but to a large extent also influenced over the centuries by human activities. Countries with presently high forest cover such as Japan and the Republic of Korea are endowed with natural conditions favouring tree growth, thus making forests the main natural vegetation type. However, after a long history of forest clearing and destruction caused by intensive use of wood as fuel, agriculture expansion and war-time activities (only in the last 50 to 60 years) both countries have restored their forest cover through significant efforts by governments and society. Today, two-third of Japan's land area is covered with forests, of which 40% are man-made plantations and the rest is natural forest. With 64% forest cover, the Republic of Korea has also recovered almost all areas where forests had been devastated in the past. Most of the forests are made of stands dominated by coniferous tree species, followed by broadleaved forests and mixed forest stands.

China, Democratic People's Republic of Korea, and Mongolia are some of the countries in the region experiencing socio-economic challenges due to poverty and food scarcity, water shortages, water quality degradation, and many interrelated factors brought by deforestation and land conversion, land degradation, loss of biodiversity, and natural disasters, among others.

China, the second largest country in Northeast Asia after Russia, has experienced deforestation and forest degradation over many centuries. Early agricultural civilization, rapid population growth, numerous wars and migration events, and irrational forest resources development have contributed to forest degradation. In 1949, only about 9% of China's total land area was covered with forests and trees. For example, the major natural forests in the Northeast, the Southwest, and the Southeast had gone through a period of rapid degradation from 1700 to 1949 with significant decline in forest cover. Large-scale afforestation efforts between 1949 and today have significantly expanded the forest area and resulted in a total forest cover of about 18%. Because of these massive reforestation activities China's forest ecosystems are today dominated by young stands with profound implications for their ecological function and sustainable management.

The Democratic People's Republic of Korea has about 9 million ha of forests or 72.5% of the total land area. Most of the forests are concentrated in the inland regions of the country dominated by high mountain ranges. Economic challenges over the past decades associated with the need to expand agricultural production have led to significant deforestation. In addition, the policy towards self-reliance in terms of food production and energy has further degraded large areas of forests, resulting in an accelerated loss of biodiversity, increased soil erosion and deterioration of vital hydrological dynamics. The forests are dominated by stands of coniferous trees, followed by deciduous broad-leaved species and also mixed forests of coniferous and broad-leaved trees.

The vegetation of Mongolia comprises plants of two large floristic regions - the Siberian Baikal *taiga* in the north and the central Asia *steppe* desert in the south. The main forest region located in the northern part of the country along the Russian border forms a transition zone between the Siberian taiga forest and the central Asian steppe zones. The forested regions of the country can be broadly divided into predominantly coniferous forests of the north and shrub forests of southern deserts and desert steppe.

Today, it is estimated that Mongolia's forest land covers less than 12.4 million ha, with a further 3.6 million ha of degraded forest and 1.8 million ha of non-forestland. Forest fires, by far, have the most serious impact on the forests of Mongolia and are mostly of incendiary nature, caused by herders and collectors of non-timber forest products. Uncontrolled fire is a major factor which determines spatial and temporal dynamics of forest ecosystems. It also drives the trend of forest formation, varying with altitude. Aside from fire**,** logging also has a negative impact on forest ecosystems. Logged areas have increased drastically over the past 20-25 years with a large portion of clearcut areas still not yet recovered. Other causes of deforestation and forest degradation are mining activity, uncontrolled grazing and lack of pasture management, collection of wood for construction and fuel, hay-making in forest steppes, complacency in enforcement of forest rules and regulations, and damage by pests and diseases. All of these contribute to the loss of biodiversity and desertification in the country.

In comparison, the history of Russia's forests in Siberia and the Far East is quite different, as for a long time people did not pay much attention to forests. Due to their vast extent, forests appeared to be an inexhaustible resource. Although population density in most of the Asian part of Russia remained comparatively low, the expansion of agriculture activities gradually reduced the forest area in certain regions. Increasing demand for timber, particularly for the shipbuilding industry in the 18^{th} Century, led to the introduction of sustainable forest management practices. This new concept was especially promoted by Tsar Peter the Great. However, improper application and enforcement of new forest laws combined with large-scale conversion of forests to agricultural land contributed to a significant loss in forest areas in certain regions. Today, some 40% of the Russian territory is covered by forests with the largest tracks located in the Siberian taiga and the Russian Far East. Species composition varies from coniferous to hard- and soft-leaved forests with mixed stands dominating most of the forests. The main focus in many forests in the Asian part of Russia is on sustainable management for timber production after first-round logging in primary forest stands.

The history of forest land use change in Northeast Asia shows that individual countries today are faced with two distinct different points of departure for their forest rehabilitation work: (a) bare land in need of afforestation/reforestation and (b) re-established forests in need of ecological restoration.

In countries such as DPR Korea, Mongolia and some major regions of China, the main challenge is to expand their forest resources through afforestation/reforestation, aiming at the prevention of further soil erosion and desertification, rebuilding new wood resources for construction and energy purposes, enhancing cash and subsistence income for local people and thus contribute to poverty reduction. Other countries like Japan, the Republic of Korea and some regions of China have reached their reforestation targets and are today concentrating on ecological restoration of re-established forests for biodiversity conservation, improvement of species composition, and enhancement of ecological functions and environmental services such as water, air, scenic values and recreation. In Russia, because of a rather longer history of sustainable forest management, rehabilitation efforts represent a mix of re-building wood resources for timber production and ecological restoration for biodiversity conservation and enhancement of environmental services from forests.

3. Responses to Forest Rehabilitation Needs

3.1 Forest Policy and Legislation

The negative effects of decades of deforestation and forest degradation on the environment and people in Northeast Asia have led governments to develop policies that promote the expansion and rehabilitation of forests. As experiences have shown, the single most important legal aspect is ownership, which is fundamental to the success of any reforestation activity. Without clear ownership, i.e. who is responsible and willing to plant and manage trees, it is impossible to carry out reforestation activities and subsequently manage these forests on a sustainable basis.

In Japan, for example, a long process of establishing clearer ownership over forests commenced in the mid 19th Century when for the first time forest land was classified into national forests, communal forests and individual ownership of forests. In combination with other laws such as the Forest Act, the River Act, and the Soil-Erosion Control Act, a clear legal situation was established for investments into reforestation and forest rehabilitation. This resulted in significant investment into replanting schemes on public forest land with the establishment of 330,000 hectares of forest plantations.

In the case of China, the rapid economic development and associated growing demand for forest products and environmental services in recent decades has shaped forest national policies. Forestry identified by the government as one of the core sectors for sustainable development received major funding for reforestation and forest rehabilitation. Other legal and regulatory instruments were created to support sustainable forest management. Such instruments included forest harvesting quotas, compensation for “ecological forests” primarily providing non-marketable environmental services, fiscal policies, and laws on forest rehabilitation in specific eco-regions of the country. Additionally, an inadequate land tenure system in China in the past had been identified as one of the main obstacles to successful reforestation. The problem has been addressed by allocating to specific households or individuals the rights to forest land and/or use of forest products. In this way a liberalisation of the forest product markets and more active participation of farmers in forestry development could be achieved.

In contrast, over the past 300 years Russia had already implemented forest legislation that ensured rehabilitation of land either after clearcutting during timber harvesting and mining, or reforestation of treeless areas in the southern region of the country.

Given the fact that the Republic of Korea has largely achieved its targets of reforestation and forest rehabilitation, the major focus of the current National Forest Plan is to build forest management policies addressing the diverse socio-economic needs with due consideration and guidance by international trends and policies. Several laws and regulations related to erosion control, forestry cooperatives, promotion of forestry and mountain villages, promotion of forest arboretum, and the Forest Land Management Act have been amended over the years and positively contributed to rebuilding forest resources in this country.

In consideration of the growing concern over land degradation, the government of DPR Korea is implementing policies and legislations designed to preserve land resources and promote its sustainable use. Key aspects of the government’s land management policies include a land development master plan emphasising a gradual increase in forest area while avoiding the encroachment on existing farmland; improvement of the management of mountains and rivers as an important means of securing safe agricultural production; improvement of the livelihood of rural communities in mountainous areas through the integrated management of natural resources; protection of the land from pollution and increasing the effectiveness of land use; and promotion of broad participation and partnerships in protection and management of land resources.

Over the past 15 years, Mongolia has experienced radical changes towards creating a democratic society. The move from a centrally planned system to market economy required the establishment of new legal frameworks and policies with significant bearings also on the forestry sector. The Mongolian Action Programme for the 21st Century underlines the challenges faced by Mongolia in the use and expansion of specially designated areas of the country's precious forest resources for important economic activities, while at the same time, make it possible to set aside critical forest areas as protected ecosystems where only non-destructive uses such as species protection, controlled hunting and ecotourism are to be allowed. Towards this end, several medium- and long-term plans for forest resources protection, reforestation and combating desertification have been developed and implemented.

3.2 Forest Rehabilitation Programmes and Projects

Based on the characterisation of forest development in Northeast Asia, one may distinguish between two broad categories of forest rehabilitation works: (a) afforestation/reforestation and (b) ecological restoration. Afforestation aims at establishing new forests on treeless areas while reforestation aims to rebuild forests that have been destroyed by natural causes or human activities. Ecological restoration is applied in established but degraded forests with a focus on assisting natural processes so that the forest can recover towards its original state. Ecological restoration activities are concerned with species composition, stand structure, biodiversity, and ecological functions and processes.

3.2.1 Afforestation/Reforestation

In China, 10 large-scale national programmes oriented towards expanding forest resources, soil and water conservation and environmental protection, have been implemented with the aim to prevent serious disasters and environmental degradation caused by flooding, soil erosion and desertification. Most of the activities involved the establishment of new forests through afforestation, protection of remaining heavily disturbed natural forests, and watershed management. In total, almost 1.2 million km^2 of new forests were established in the most ecologically fragile regions of China, which suffered from soil loss, water scarcity, desertification, cyclones and salinity. It is important to note that since 10 years ago the Chinese Government has adopted a western development strategy in which ecological restoration and environmental rehabilitation are major components in the process of socio-economic development. Towards this end, more emphasis is now given to issues such as protection of natural forests, mitigating negative effects of sand storms, the establishment of forests on marginal agriculture land and urban forestry to improve the environment in highly populated areas.

Responses to forest degradation have been taken at various levels in the DPR Korea. Besides establishing a National Coordinating Committee on Environment (NCCE) over-seeing the work of several ministries involved in agriculture, forestry and industries, twice a year all levels of society are mobilised to assist in land rehabilitation activities. Such projects involve the repair of river banks, re-alignment of paddy fields and reforestation. Although the project involves a large number of people throughout the country, its constraints associated with limited technical skills and inefficient use of resources have been mentioned.

A major issue related to forest management in Mongolia is reforestation, due to the difficult site conditions. Considering the specific habitat factors existing in Mongolia, in many cases sufficient natural regeneration of desired species such as pine and larch cannot be achieved after logging operations and/ or fire incidences. The share of non-coniferous species like birch and aspen increases and some areas may turn into grassland. Under such a situation, artificial planting or sowing with desired species is necessary to supplement natural regeneration establishment.

For about 30 years, the Mongolian Government has had a program of tree replanting and plantation establishment. The area successfully replanted represents only 5-7% of the total forest lost, mostly due to low survival rates of the seedlings. At present, 150,000 hectares of forest are in need of restoration. However, only 5,000 hectares are being restored annually. There are successful examples of reforestation supported by NGOs, although only small areas show the way forward for forest rehabilitation in the country. Mobilization of investment funds locally is very important in meeting at least part of future needs. Furthermore, in order to attract private sector participation it is necessary to provide investment profiles of suitable projects with relevant information and analysis.

3.2.2 Ecological Restoration

Ecological restoration is the main focus of forest rehabilitation in countries (e.g. Republic of Korea, Japan and some sub-regions of China) that have successfully re-established their forest cover after centuries of deforestation.

In the Republic of Korea, the major task of bringing back forests through afforestation and reforestation was accomplished in the late 1980s through government, NGOs, and community participation. Today, restoration projects deal mainly with the control of pest and diseases, watershed management, control of forest fire, and nature conservation in mountainous areas.

The fight against calamities caused by various biotic factors is a major concern in the Republic of Korea. Due to continuous reforestation from the 1960s to late 1980s large areas of the country are currently covered by young forests (mainly of monoculture). These forests are prone to attacks by insects (e.g. pine moth, pine needle gall midge), fungi (e.g. oak wilt disease), and wood nematodes (pine wilt disease). In order to combat these diseases, both traditional methods such as the use of chemicals and extracting of affected wood, as well as biological control methods, have been applied. The latter are under intensive study to further promote environmentally sound management.

Prevention of soil erosion, stabilisation of hill slopes and provision of adequate water supply are the main objectives of the many watershed management projects in the country. Besides thinning and pruning operations to improve stand structure and species composition, the construction and maintenance of erosion control dams and other soil stabilisation facilities are being carried out in the watershed areas on a regular basis.

Forests affected by fire are rehabilitated either through natural regeneration or artificial planting in some areas in combination with the restoration of pine mushroom (*Tricholoma matsutake*), which is a very important source of income for rural residents.

Nature conservation projects are becoming increasingly important, particularly the mitigation of forest landscape fragmentation caused by progressive industrialisation. An outstanding example towards this end is the Baekdu Daegan Mountain Range where a wide range of conservation and forest rehabilitation projects are being implemented.

After a phase of massive reforestation following World War II, a shift towards comprehensive forest management took place in Japan on the basis of four broad forest functions, namely timber production, water resources conservation, hillside erosion control, and preservation to serve public health purposes. Due to rapid economic development and the increasing demand for water resources, the area of protection forests expanded significantly. However, because of the high costs of forest operation interventions in forest stands, such as cleaning and thinning, these forest operations became unprofitable and thus have not been carried out. However, given the fact that international environmental concerns, especially related to climate change and biodiversity conservation, have increased in recent years, more investments into “non-commercial” operations in forest stands to regulate species composition and increase stand stability are likely to come.

3.3 Success Factors of Forest Rehabilitation

The Northeast Asian region has experienced both a significant decline in forest area and periods of rapid forest expansion and rehabilitation. Since the end of World War II, large areas of devastated land were reforested and degraded forest ecosystems were rehabilitated. These remarkable results could not have been achieved without specific socio-economic and political framework conditions that are critical for the success of forest rehabilitation work. The main success factors are summarised as follows:

- Economic progress and political leadership have played an important role in mobilising public support for forest rehabilitation. With the economy recovering, significant financial resources become available and could be channelled to land rehabilitation. Equally important are the vision and determination of political leaders to pursue the conservation and sustainable use of natural resources.

- Because of strong political will, voluntary public participation could be mobilised. This aspect is very strong in the Republic of Korea where massive reforestation work could be implemented with significant voluntary input by civil society.

- Non-government organizations, particularly in the Republic of Korea and Japan, played an important role in promoting public awareness on environmental issues, thereby enabling the government to increase the performance and efficiency of forest rehabilitation projects.

- In Mongolia, experiences and skills of local people in tree planting activities and active participation of local community contributed to the success of some of their reforestation activities.

- Changes in tenure systems providing more secured access to forest and tree resources have also been critical in mobilising support and cooperation of forest stakeholders.

- Strong government institutions have also been critical and provided the background for adequate enforcement of forest protection policies, national planning and coordination, and continuous financing for the forestry sector.

- Substantial international technical assistance has also contributed to the success of forest rehabilitation in Northeast Asia. Aside from financial resources, the transfer and diffusion of appropriate technology for the reproduction of planting material and land rehabilitation provided the basis for effective implementation.

- It should also be noted that the change from wood energy to fossil fuels and the import of timber from tropical countries reduced the pressure on forests, particularly in Japan and the Republic of Korea.

All in all, it can be stated that reforestation and forest rehabilitation did not turn out to be an obstacle to economic development, but on the contrary, helped stabilise other economic sectors such as agriculture.

4. Research and Educational Capacities for Forest Rehabilitation

All countries in the region have in place well-established forest research and educational systems. Modern forest research in these countries more or less started at the beginning of the 20th Century when industrialisation led to increased urbanisation of society. Today, there are many forestry universities in China, Japan, Republic of Korea and Russia. Similarly, large numbers of forest research institutes operated by federal and provincial governments cater for the information needs of forest stakeholders.

In some sub-regions, however, the number of research and educational institutions has grown significantly. Partial lack of coordination has resulted in duplication of efforts and inefficient use of available human and financial resources. Any strategy towards improving the situation needs to address the institutional aspects and to clarify the role of public sector research in a market economy driven by the private sector.

The subject area of forest rehabilitation and reforestation is well covered within educational programmes since this field is vital to the work of the majority of forestry professional in these countries. With the increased concern of society for environmental protection and conservation, forestry research and education became much broader to also include urban forestry, desertification, agroforestry, non-timber forest products, environmental education and tourism, and more recently, climate change research.

5. Recommendations and Future Actions

The experiences resulting from extensive reforestation and forest rehabilitation work in Northeast Asia described in this book provide an excellent basis for further developing the approaches and learning from one another. Although there are significant differences in the state of forest rehabilitation and objectives among the various countries, some common trends and future action can be summarised as follows:

- In countries that have thus far concentrated on expanding forest area through reforestation, a shift towards broader ecological rehabilitation approaches has been initiated. However, these approaches need to be further promoted and enhanced.

- With the increasing importance of environmental services from forests that are usually not directly marketable, new compensation schemes (e.g. fund or market-based) need to be introduced.

- Further work is to be done to clarify and strengthen tenure systems to define management responsibilities and benefit-sharing mechanisms.

- Capacity building, public awareness and transfer of technologies are still needed in some countries in the region, such as China, DPRK, and Mongolia, to rehabilitate degraded lands and sustainably manage their existing forest lands.

- There is also a need to promote monitoring and evaluation systems at the forest and landscape levels to better describe the benefits of forest rehabilitation and thus justify investments in the long-term conservation and sustainable management of forests.

- Improving the productivity levels of forests (particularly for timber) is considered a priority in some regions, while in others a better integration of forest and trees into farming systems such as agroforestry and silvopastoral management is required.

- At the same time, environmental considerations, such as the conservation of biodiversity and watersheds, prevention of soil erosion, forest health and climate change mitigation, continue to be important aspects for future forest rehabilitation work.

Forest Rehabilitation in Mainland China[1]

Bin Wu, Zhiqiang Zhang and Lixia Tang[2]

1. General Information

1.1 Geographic Information

Located in the eastern part of Asia and on the west coast of the Pacific Ocean, China is the third largest country in the world with a total land area of 9.6 million square kilometers. The distance from east to west measures over 5,200 kilometers, and from north to south over 5,500 kilometers. Besides a vast land area, there are also extensive neighboring seas and numerous islands. The coastline extends along more than 14.500 kilometers. Across the East China Sea to the east, and South China Sea to the southeast, are Japan, the Philippines, Malaysia, and Indonesia. More than 5,000 islands are scattered over China's vast territorial seas, the largest being Taiwan and the second largest, Hainan. One territorial sea and three neighboring seas altogether constitute 4.73 million square kilometers.

China is a mountainous country, with two-thirds of its total land area covered by mountains, hills, and plateaus. There are five major mountain systems in China. These mountain systems, together with numerous inter-montane plateaus, basins, and plains are interwoven into three macro-landform complexes in China. Therefore, the topography of China from the Qinghai-Xizang Plateau eastwards, can be describe with the help of four broad elevation zones descending step-by-step from the Qinghai-Tibet Plateau to the coastal area in the east.

The Qinghai-Tibet Plateau, the top of the staircase, covers 2.2 million square kilometers and averages 4,000 meters above sea level. From the eastern margin of Qinghai-Xizang Plateau eastward up to the Da Hinggan-Taihang-Wushan mountain line, the area is composed mainly of plateaus and basins with elevations ranging from 2,000 to 1,000 meters. Up to the coast the largest plains of China are located. The plains are also interspersed with hills, generally below 500 meters in elevation.

China has a great number of rivers and lakes. The inland river system accounts for 36 per cent of the total land area in China. The Changjiang River, Yellow River, Heilongjiang River, Pearl River, and Huaihe River are the major ones. The Changjiang River is the longest river in China and the third longest in the world with a total length of 6,300 kilometers and a watershed area of more than 1,800 square kilometers. The Yellow River is the second longest river in China with a total length of 5,464 kilometers. The Yellow River valley is considered the cradle of Chinese civilization. China is also a country with numerous lakes. There are approximately 2,800 natural lakes with a total area of more than 80,000 square kilometers.

1.2 Population

China is one of the most populated countries in the world. According to data published by the China Population Information and Research Center (http://www.npfpc.gov.cn/en/edatachina.htm), the total population of China in 2002 is 1,276.27 million. The crude birth rate, crude death rate, and natural increase rate in 2002 were 12.86%, 6.41%, and 6.45%, respectively. It was projected that the total population of China will be 1.47 million and 1.53 million in 2020 and 2050 respectively. The birth rate and net increase rate of population in China will be 12.80% and 4.77% in 2020, and 11.34% and -1.83% in 2050.

[1] All the information provided in this report is referred to Mainland China.

[2] College of Soil and Water Conservation at Beijing Forestry University, Qinghua East Road 35#, Haidian District, Beijing 100083, P.R. China

1.3 Economic Situation

After more than a quarter century of reform and opening to the outside world, by 2005, China's economy had become the second largest in the world after the United States when measured on purchasing power parity (PPP) basis. The government has the goal to quadruple the gross domestic product (GDP) by 2020 and more than doubling the per capita GDP. Central planning has been curtailed, while wide-spread market economic mechanisms and a reduced government role have prevailed since 1978.

The government fosters a dual economic structure that has evolved from a socialist, centrally planned economy to a socialist market economic system, or a "market economy with socialist characteristics." The industry is marked by increasing technological advancements and productivity. People's communes were eliminated by 1984 – after more than 25 years – and the system of township-collective-household production was introduced to the agricultural sector. Private ownership of production assets is legal, although some nonagricultural and industrial facilities are still state-owned and centrally planned. Restraints on foreign trade were relaxed when China acceded to the World Trade Organization in 2001. Joint ventures are encouraged, especially in the coastal special economic zones and open coastal cities.

A sign of the affluence that the reformed economy has brought to China might be seen in the number of its millionaires (measured in U.S. dollars): a reported 236,000 millionaires in 2004, an increase of 12 percent over two years earlier.

China is facing a variety of challenges influencing the nation's future economic development. The major challenges include: to maintain a high growth rate, deal effectively with the rural workforce, improve the financial system, continue to reform the state-owned enterprises, foster the productive private sector, establish a social security system, improve scientific and educational development, promote better international cooperation, and change the role of the government in the economic system. Despite the constraints the international market has placed on China, it nevertheless became the world's third largest trading nation in 2004 after the United States and Germany.

The Eleventh Five-Year Plan (2006-10) emphasizes a shift from extensive to intensive growth in order to meet demands for improved economic returns, the conservation of resources to include a 20-percent reduction in energy consumption by 2010, and an effort to raise profitability. Better coordination of urban and rural development and of development between nearby regions is also emphasized in the new plan.

2. Forest Related Environmental Issues

The large area of mountains making up 2/3 of the total area of the country provides the topographical background for the occurrence of soil erosion, torrents, landslides, and debris flows while desert landscape in the northern part of the country provides sand dust sources for wind erosion and sandstorms. On the other hand, the extensive human activities such as overgrazing, reclamation, deforestation, slash and burn agriculture accelerated the rate of ecological degradation and environmental destruction. Soil erosion, desertification, biodiversity loss, and land degradation are major forest related ecological and environmental problems in China.

2.1 Soil Erosion

According to the national soil erosion survey in 1989, the total eroded land area was up to 3.67 million km^2 amounting to 38.2% of the total area of the nation's territory, of which 1.79 million km^2 caused by water erosion and 1.88 million km^2 by wind. Each year, about 5 billion tons of surface soil is eroded causing huge amounts of organic material, C, N, P, and K to be transported to national water bodies like rivers, lakes and reservoirs.

2.2 Desertification

In accordance with the definition of the UN Convention to Combat Desertification, the total area of degraded land affected by desertification in China is up to 2.62 million km^2, amounting to 27.2% of the nation's territory. The land area desertificated by water and wind erosion overlaps with that of the same type of desertification in dry-land regions. A large number of farm lands, grazing lands, forested lands, and many highways, railways and city establishments are harmed by desertification. It is estimated that the direct economic toll by desertification each year is as high as 54 billion RMB Yuan (approximately 6.5 billion US$) and over one-third of the total population of the country is threatened by disasters of desertification. The desertificated land area is distributed mainly in the Northern and Northwest parts of China covering 18 provinces. The desertification rate by wind erosion increased from 1.56 thousand km^2 per year in the 1960s and 1970s to 2.1 thousand km^2 in the 1980s. However, the increase in wind erosion reached up to 2.46 thousand km^2 each year in the 1990s. One of the most influential phenomena closely related to desertification are sand dust storms that have occurred frequently in China in recent years. However, the total degraded area has continuously been decreasing by 1280 km^2 each year since 2000 due to massive efforts directed towards combating desertification (Editorial Board of the Third National Desertification and Sandification Inventory Report, 2006).

2.3 Water Contamination, Floods, and Droughts

China is a "rich country in water resources" from the viewpoint of the total amount of water, but on the other hand, unfortunately, a "poor country in water" in terms of the availability of water per capita. The annual amount of river runoff in China is 2711.5 billion m^3, ranking sixth in the world. However, the amount of annual per capita water resources is only 2 474m^3, 1/4 of the world annual per capita water resources of 9360 m^3, ranking 88th in the world (Changming Liu, 2001).

Water resources are unevenly distributed all over the country in terms of area and season. In the south, the rainy season is longer, and the rainfall from March to June or from April to July accounts for about 50% to 60% of the annual rainfall; while in the north, the rainy season is shorter, and the rainfall from June to September accounts for about 60% to 70% of the annual rainfall, often occurring in the form of rainstorm. As a result of over concentration of rainfall, flood and waterlogging occur frequently, while drought is likely to occur in the season short of rain. Water quality and environmental degradation is another serious problem in China. Pollution of water quality further aggravates the shortage of water resources. Waters from about 1/2 of the nation's river systems have been polluted. For the Yellow River, about 71% of the whole distance has been polluted and the water of 105 rivers of the 136 rivers flowing through city areas can not be used for drinking. According to statistics, 80% of unprocessed wastewater is drained directly into rivers, lakes, streams and reservoirs, polluting more than 1/3 of the rivers and water supply in some cities and towns, impairing the people's health and living conditions.

Drought disasters have also very frequently occurred in China putting great pressure on the nation's agricultural development.

2.4 Grassland Degradation

Overgrazing and low maintenance has resulted in grassland degradation at the speed of 20 thousand km^2 each year. It is estimated that the total degraded grassland amounts to about 1.3 million km^2.

2.5 Biodiversity Loss

Ecological and environmental degradation, specifically in forest ecosystems accelerated the loss of terrestrial biodiversity. It is estimated that about 15% to 20% of floral and faunal species in China are in danger of extinction.

3. Current National Policy and Legislation

Three major driving forces have shaped the national forestry policy and legislation reforms in China. The ever growing demand for forest products and ecological and environmental services provided by forest resources in China along with the rapid economic development are the main driving forces behind the massive forestry program in recent years. The development of a domestic market economy influenced the resources allocation away from the former centrally-planned economic system in China. As one of the biggest countries in the world, China takes its responsibility to address global environment issues by developing large scale forest rehabilitation programs.

3.1 Forestry as the Core Sector to Achieve a Sustainable Development Strategy

Large scale forest rehabilitation during the past decades in China has been supported by favorable national policy and government investment. The rapid increase of government investment in the forestry sector has been the major funding source over the past decades to rehabilitate degraded forests in China. In addition to the central government's investments in forest rehabilitation, provincial, regional, and county level governments also increased their financial support to forestry development. Although major funding for those programs comes from the central government, provincial government funds, labor cost invested by local farmers are all indispensable for implementing such large scale forestry programs.

3.2 Forest Harvesting Quotas in China

The logging quota system was introduced in the early 1980s to prevent the further degradation of Chinese forests. This system is devised to determine the upper limit of timber harvest on the principle that the total amount of timber harvested per year should be less than the annual increase in forest stocking. The county-level forest administration requires to apply for a timber harvesting quota to be approved by both the provincial-level forestry and state forestry administration. However, the scientific basis for the determination of the forest harvesting quota has been questioned. The market-driven demand for forest products and the unclear and complex forest tenure arrangements have made the effectiveness of the system questionable.

3.3 Compensation for Ecological Forests

The forests management strategy adopted in China in the early 2000s categorized forest resources into commercial forests and ecological forests. In 2002, the Ministry of Finance and the State Forestry Administration issued administrative guidelines for the financial compensation of reserving forests for ecological functions setting the annual compensation fee at 10 US$/hm^2 year $^{-1}$. There have been many follow-up compensation schemes for ecological forests by the central, provincial, and city governments to pay to land owners in order to prevent logging and degradation of ecological forests. However, the low compensation fee turned out to be very ineffective and due to different rates applied across regions forest owners felt that they were unfairly treated. The uniform compensation fee for national ecological forests is 5yuan/mu across the country. However, this rate is as high as 50US$/hm^2 year $^{-1}$ for Beijing and Guanghzou. To increase the ecological forest compensation fee or payment for ecological forests will be one of the most important policy instruments to prevent the degradation of forests.

3.4 Fiscal Policy

In addition to the rapid increase of government investments in the forest sector, provincial, regional, and county-level government investment, and labor contributions by local farmers have been indispensable for implementing six large-scale national forestry programs to rehabilitate degraded forests in China over the past two decades. In order to attract local farmer support for implementing these programs, the economic output of forest rehabilitation projects has always been considered.

Although there is strong demand that the government should be the main investor in support of the rehabilitation of ecological forests and the fact there has been a dramatic increase of central government revenue from the forest sector, the funding requirements for forest rehabilitation by far exceeds the ability of the government.

The introduction of market mechanisms along with government support for key forestry industries and commercial forestry projects further promotes the commercial forestry development in China which in turn also favors rehabilitation for ecological forests. Commercial forestry development is also supported by financial instruments such as bank loans and stock markets.

3.5 Forest Tax and Fee System

The complex income tax system in the Chinese forest sector includes state level and local-level taxes. State-level taxes are a 6 percent value-added tax, an education surcharge of 3 percent of the value-added tax, and a tax on urban construction while local income taxes include a special tax for agriculture and forest products (Sun Changjin, 2002).

According to reports the current complex fee system in the forest sector could be as high as 50 to 70% of which approximately 20% are legal taxes, 20% forest cultivation fees, and 20% are charged by other sectors(Changjin Sun, 2002). The forest cultivation fee collected after timber harvesting by the forest sector can be as high as 27% of the selling price for planting, maintenance, forest protection, and construction (Changjin Sun, 2002).

3.6 Forest Land Tenure System

China's state-owned land system is considered the main obstacle for more equitable access to and use of forest resources. However, private use rights and ownership of forest products on collectively-owned as well as state-owned forestland is protected by the Forest Law issued in 1998. There are two kinds of collectively owned forests. Forestland on freehold mountains is contracted to individual households which are allowed to harvest and process forest products based on approved harvesting allowances. Single households or household groups are encouraged to enter into contracts (responsibility mountains) to manage forest areas on mountain terrain. Those who develop the land and plant trees will be granted land use rights for 50 years. The policy also allows for private ownership of forest products and the transfer and lease of land-use rights after the land has been developed.

The forest land tenure reform targeted to liberalize the forest product market and promotion of active involvement of farmers in forestry development has been initiated in recent years. Collectively owned forest land has been allocated to individual households, in order to clarify the individual use rights. The owner of forest has the right to manage, use, lease, or transfer the forests for a specific period of time. A forest and wood exchange center was established in some major collectively owned forest regions such as Fujiang and Jiangxi provinces in order to assist farmers in the transfer of forestland according to market principles.

China's national forest policy is program-specific. Therefore, we present two national programs as example to illustrate aspects of the national forest policy in addition to the general introduction to the forest sector as described above.

3.7 Policy for the Natural Forest Protection Program

The National Forest Protection Program (NFPP) was initiated in 1998 as response to the catastrophic floods. The program aims to reverse the continuous degradation of natural forests in China and ensure the environmental services and functions provided for the nation's major water systems. A wide range of national policy measures were initiated to counteract the economic and social problems resulting from the total logging ban in watershed areas. These measures include reassignment of forestry workers, provision of central government subsidies to local governments whose revenues have been impacted, tax reductions and subsidies to forest enterprises for reorientation of activities, provision of basic living allowances for laid-off workers, creation of an insurance of unemployment, encouraging forest farmers to shift to agro-forestry systems to increase income, and providing salaries for workers in forest planting projects in deforested areas.

Recently, the total ban of forest harvesting also raised questions about the sustainable management of forest resources in natural forest areas. Over the past years there has been the call for reforming the current total logging ban in order to reconcile the requirements of forest products markets and the conservation of natural forests.

3.8 Policy for the Conversion of Cropland to Forests and Grasslands Program

The Conversion of Cropland to Forests and Grasslands Program (CCFGP) was initiated in late 1999 and a new round of government support has been approved by the central government this year (http://www.tghl.gov.cn/baodao/baodao_show.aspx?id=2000). The total budget for this new round of government support for farmers who convert their agriculture land into forest is 28 billion US$ over the next 8 years. Specifically, the national policy for CCFGP program includes:

1) Provision of grain to farmers. The central government provides 2250 kg of grain foods as subsidiary for 1 hectare of converted steep farmland in the upper reaches of the Changjiang River and 1500 kg in the upper and middle reaches of the Huanghe River, respectively. The duration of support given to farmers depends on the type of reforestation. The time span is 5 years for cash tree plantations and 8 years for ecological forest plantations. After this time span, farmers will get grain compensation on the basis of the evaluation of their income;

2) Provision of seedlings and forestation expenses;

3) Provision of cash compensation for households;

4) Guarantee of the property right. The households that manage the converted land will obtain benefits from it. In case farmers are not willing to manage the converted land, the local government is allowed to rent it to other farmers through an auction system according to national laws. Multiple approaches to promote the conversion can be pursued by local expert households for afforestation, social communities, as well as private enterprises. They are all encouraged to rent slope land for forestry development. Households are encouraged to re-build forest and grass and are allowed to manage the land for periods as long as 50 years;

6) Reductions of agricultural taxes for the households;

7) Fiscal transfer payment mechanisms. Financial support by the central government is directly paid to local farmers;

8) Expenditures for demonstration and technical support activities during the implementation of the conversion project are also covered by the central government.

All in all, this conversion project has been carried out in accordance with China's poverty alleviation campaign, and various agricultural integrated development and soil and water conservation initiatives. The budgets from different government sectors have been combined and besides reforestation activities the funds can also be used for the construction of infrastructure for agricultural development such as terrain alterations and small water structures and for technical training of farmers. All such activities are intended to promote the conversion project.

3.9 Laws on Forest Rehabilitation

Effective legal or institutional measures have been taken to ensure the development of forest rehabilitation efforts. Relevant legislation in relation to the nation-wide efforts to forest rehabilitation has been gradually established since the 1980s in line with the increase of national investment to further prevent the degradation of land and forest resources throughout China. The most important laws include:

- Forest Law of the People's Republic of China (Jan., 1988)
- Law of Environmental Protection of the People's Republic of China (Dec. 26th,1989)
- Soil and Water Conservation Law of the People's Republic of China (June,1991)

- Grassland Law of the People's Republic of China (Oct., 1985)
- Law of Mineral Resources of the People's Republic of China (Oct.,1986)
- Land Management Law of the People's Republic of China (Dec.,1988)
- Law of Agriculture of the People's Republic of China (July, 1993)
- Law on Desertification Combating (2002)
- Regulations on Converting Farmland to Forest
- Resolution to Further Strengthen Desertification Combating
- Resolution to further strengthen the forestry development

4. Status of Forest Rehabilitation

4.1 History of Forest Degradation

Forest degradation in China is closely correlated with the history of land use. Early agricultural civilization, rapid population growth, numerous wars and migration events, and irrational forest resources development have contributed to degradation. This resulted in low forest cover with only 8.6% of the total land area of China in 1949 stocked with forests and trees (Figure 1).

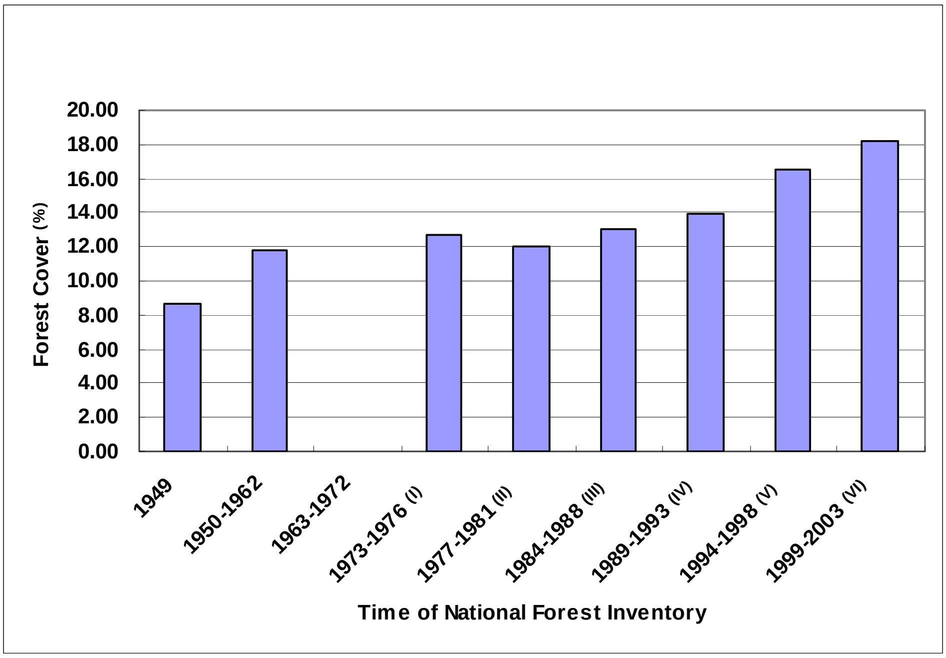

Figure 1: ***Total Forest Cover Change over 1949 to 2003 in China***

A recent study shows that over the past 300 years a total area of 95 million ha (0.95×10^8) or 9.2% suffered from deforestation (F.N He et al., 2007). The forest area was reduced by 166 million ha (1.66×10^8) or 17% in 260 years before the 1960s, but rapidly increased by 70 million ha (0.7×10^8) or 8% in 40 years after the 1960s (F.N He et al., 2007). In addition, China's major natural forests in the Northeast, the Southwest, and the Southeast had gone through a period of rapid forest degradation from 1700 to 1949 with 20% forest coverage decline for most of the provinces in these regions (F.N He et al., 2007). The driving forces for deforestation and recovery were not analyzed in this study.

The increase of forest cover from 8.6% in 1949 to 18.21% in 2003 was mainly due to large scale afforestation (Shuoxin Zhang & Conghe Song, 2004). Intensive timber harvesting in natural forests before the logging ban in the late 1998 caused substantial natural forest degradation in China. Large scale afforestation, intensive logging, and reforestation have made the forest ecosystems in China become dominated by young stands with profound implications for their ecological functions within terrestrial ecosystems.

4.2 Causes of Forest Degradation

The causes of forest degradation in China are very complex and have changed over time. However, extensive agriculture development, population growth, numerous wars, logging, forest fire, diseases and insect calamities, environmental stress, and the over-exploitation of water resource are major driving forces for forest degradation.

Population Growth and Wars

The Chinese population of the Qing Dynasty increased from 81.64 million in 1644 to 431.89 million in 1911 while the forest area decreased from 21% to 15% during the same period (Research Team, 2003a). In addition to population growth, foreign invasions into China brought a series of unfair treaties with the Emperors of the Qing Dynasty upon which large forests were cut leading to unprecedented degradation of forests in China. For instance, during the Japanese invasion and occupation of China from 1937 to 1945, over 10% of Chinese forests were destroyed. Dramatic deforestation from 1911 to 1949 reduced the country's forest coverage from 15% to 8.6% (Research Team, 2003a).

Past Extensive Agricultural Development

Forestland has been continuously converted to crop land for food production throughout the history because of the rapidly increasing population in China. It is reported that the forest coverage in Yunnan Province has been reduced from 40% in 1948 to 24.58% in 1993 due to population growth and agriculture development.

Extensive Long-term Logging

Timber harvesting in Chinese forests has been ongoing for a long time because of the nation's dependency on forestry industries. As a result of logging and the absence of rehabilitation measures most of the forest areas have been heavily degraded. The forest harvesting quota policy is one of the most controversial policies in China, and particularly its effect on forest degradation and rehabilitation. Some research pointed out that the actual timber harvest has long exceeded approved logging quotas and that the system has not been a very effective instrument to prevent forest degradation (Jintao Xu, 2002). According to reports, the actual annual timber harvest from 1994 to 1998 was by 33.8% higher than the annual logging quotas while the total area of forest plantations decreased by about 1.24 million hectares and the natural forest area declined by 0.88 million hectares during the same period (Jintao Xu, 2002). The situation is even worse in state-owned forests. National forest inventories data show that the forest quality has not considerably improved from early 1981 to 2003 when data of the fifth inventory were released (see Table 1).

Forest Fire, Diseases, and Pests

About 676,000 (6.76×10^5) forest fire incidences occurred in China from 1950 to 2000 averaging 13,500 (1.35×10^4) fire events annually. The total area deforested by fire each year is estimated at approximately 822,000 ha (82.2×10^4) with the most affected regions of natural forests located in the northeast and southwest of China (SFA, 2002. 1986~2001 China Forestry Statistic Data. Beijing: China Forestry Press). Poplar plantations in northern China suffered from severe attacks of the Asian Longhorn beetle while pine forests from north to south were affected by pine beetle calamities.

Environmental Stress

Results of numerous scientific studies and monitoring data show that acid rain occurs in many regions in Southern China, amongst others causing low growth rates of timber trees. It is estimated that in 11 provinces in Southern and Southwestern China the annual economic loss in timber production is up to 18 million RMB Yuan and that related to ecological and environmental services is 160 million RMB Yuan

Table 1: ***Stock Volume & Timber Harvested in China in the Period 1949 to 2003***

Years	Total volume in stock ($x10^9m^3$)	Mean volume density (m^3/ha)	Total volume growth ($x10^6m^3/yr$)	Total volume harvested ($x 10^6m^3/yr$)
1949	–	–	–	–
1950 - 1962	10.2	98.9	126.0	87.8
1963 - 1972	–	–	–	–
1973 - 1976	9.5	79.0	226.9	195.6
1977 - 1981	10.3	83.4	275.3	249.1
1984 - 1988	10.6	79.2	316.0	344.0
1989 - 1993	11.8	83.2	420.0	320.0
1994 - 1998	12.5	78.1	457.5	370.0
1999 - 2003	13.6	84.7	497.0	365.0

(Zongwei Feng, 2000). Acid rain can cause substantial forest degradation by negatively influencing natural regeneration, succession processes, and the growth of forest ecosystems.

Over-Exploration of Water Resources in Northwest China
The inland river basin in northwestern China has suffered from excessive water resources exploitation and related forest degradation. For instance, large parts of the native *Populus enphratica* forest along the Rarim River in Xinjiang have been degraded and disappeared due to intensive agriculture cultivation upriver using up most of the water resources. Another example is the Shiyanghe River located in Ganxu Province, where over-exploitation of upper-reach river water resources led to shrinkage of the oases located down-river accelerating the desertification processes. In this region, water availability plays a significant role in forest rehabilitation. The over exploitation of water resources will lower the groundwater level which supports the native forest vegetation establishment and growth. It is estimated that the water resources needed for vegetation rehabilitation in the inland river basins of northwestern China could be as high as 20 billion m^3 annually (Guofang Shen, 2001).

Construction and Land Resources Exploitation
It is reported that 2.81milion hectare of forestland has been converted to other land uses (Research Team, 2003b).

5. Trends in Rehabilitation of Degraded Forests

China has a long history of forest rehabilitation efforts. The continuous and significant increase of forest coverage from 8.6% in 1949 to 18.21% in 2003 and improvement of the quality of forests (see Table 2) has tremendously contributed to improving global forest resources (FAO, 2006). The liberalization of the forest industry as part of the economic market reform and rapid expansion of the Chinese economy has shifted the focus of China's forestry from timber harvesting to broader ecological rehabilitation and restoration.

Realizing the environmental constraints facing the country and importance of forest ecosystems for the restoration of the degraded environment, the Chinese Government has been prioritizing forest rehabilitation and restoration since 1978. Especially after the 1998 catastrophic flood event in the Changjiang River, the central government funding for forest rehabilitation and restoration has increased dramatically. The major objectives of Chinese forest rehabilitation and restoration are targeted towards soil erosion control, combating desertification, protection of biodiversity and habitat restoration, flood mitigation, water purification, carbon sequestration, as well as mitigation of air pollution and overall global warming.

The second objective of forest rehabilitation is to provide forest products and material for the livelihood of people.

Table 2: ***Standing Timber Stock, Forest Area, Wood Stock, and Forest Coverage of NFI from 1973 to 2003***

Time Period of NFI	**Total volume in stock ($x10^8m^3$)**	**Forest area (10^4/ha)**	**Forest coverage (%)**
1st NFI (1973-1976)	95.32	1.22	12.70
2nd NFI (1977-1981)	102.61	1.15	12.00
3rd NFI (1984-1988)	105.72	1.25	12.98
4th NFI (1989-1993)	117.85	1.34	13.92
5th NFI (1994-1998)	124.88	1.59	16.55
6th NFI (1999-2003)	136.18	1.75	18.21

5.1 Implementation of Large Scale National Forestry Programs

Ten national forest eco-engineering projects oriented towards soil and water conservation, environmental protection and expanding forest resources have been carried out since 1978. They are:

1) "Three North" (Northwest, Northern China, West of the Northeast) Protection Forests Construction,

2) Protection Forests Construction Project in the Upper and Middle Reach of Changjiang River,

3) Protection Forests Construction Project of Seashore,

4) Greening the Flat Area of China,

5) Greening Taihang Mountain Project,

6) Desertification Combating Project,

7) Protection Forests Construction for the Integrated Watershed Management of Hui River and Taihu Lake,

8) Protection Forests Construction in the Middle Reach of Huanghe River,

9) Protection Forests Construction for the Integrated Watershed Management of Liaohe River, *and*

10) Protection Forests Construction for the Integrated Watershed Management of Zhujiang River.

The targeted area of these ten projects formulating a general framework of Chinese forestry eco-engineering activities is 7.06 million km^2 amounting to 73.5% of the national total territory. It includes an afforestation area of 1.17 million km^2 covering most ecologically fragile regions of China which suffered from soil and water loss, desertification, cyclone, and salinity.

Since 1999 the Chinese government has adopted the western development strategy in which ecological restoration and environmental rehabilitation is one of the major components in the process of socio-economic development. This has also been the reason for starting another two projects entitled "Demonstration Project of Agriculturally Used Slope-land Conversion to Forest Use in the Upper and Middle Reaches of the Changjiang and Huanghe Rivers" and "Natural Forests Protection Program."

In the year 2000, the State Forestry Administration integrated all above-mentioned forestry programs into 6 key projects.

1) Natural Forest Protection Program;

2) Protection forest planting in the "Three North" and lower reaches of Changjiang River;

3) Agriculturally Used Slope-land Conversion to Forest Use Project;

4) Desertification by wind erosion control project around Beijing;

5) Wildlife animal and plant protection and nature protection reserve construction project; *and*

6) Commercial forestry (i.e. mainly fast growing wood plantations for commercial harvesting).

a) The Natural Forest Protection Program (NFPP)

The NFPP program aims at protection, rehabilitation, and restoration of natural forests. The program covers 734 counties and 167 forest industry bureaus in key state-owned forest areas in 17 provinces in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River as well as the northeast and Inner Mongolia. Three major objectives are expected to be achieved during the period of 2000-2010.

1) The existing forest resources will be protected in a proper manner. A logging ban is put on commercial harvest of natural forests in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River. The timber output in such key state-owned forest areas as the Northeast and Inner Mongolia is adjusted and reduced by 19.905 million cubic meters, and 94.2 million ha of forest are brought under strict conservation;

2) Efforts are accelerated in developing forest resources. An additional 14.66 million ha of forest and grassland, including 8.66 million ha of forest, are established in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River so as to raise the forest cover by 3.72%; *and*

3) A total of 741,000 redundant forest workers in the program area are properly redirected and relocated.

b) Conversion of Cropland to Forest Program

Soil erosion from steep agriculture lands is the main source of sedimentation in large rivers across China. Annual crop growing and livestock grazing on deforested lands with a slope of over 25 degrees can accelerate soil erosion dramatically and induce the on-site land degradation and off-site sedimentation and water pollution. This program has been designed to prevent agricultural soil erosion. The program covers 24 provinces (autonomous regions or municipalities). It is expected that 14.66 million ha of cropland will be converted to forest and 17.33 million ha of barren land covered with trees during the period of 2001-2010. Upon completion of the program the forest and grass cover of the program area will be raised by 5%, 86.66 million ha of soil- and water-eroded area brought under control and 103 million ha of sand-fixation areas established.

c) The Sand Storm Control Program for Areas in the Vicinity of Beijing and Tianjin

The program was designed to combat the sandstorms in areas surrounding the capital city of the country. The program covers 75 counties, with a total area of 460,000 square km, in five provinces, including Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia. It was expected that during the 2001-2010 period 2.63 million ha of cropland will be converted to forest, 4.94 million ha of plantations established, 10.63 million ha of grassland harnessed, 113,800 supporting water conservation facilities developed, 23,000 square km of catchment area managed and 180,000 people relocated for ecological reasons. Upon completion of the program the ecosystem in the areas in the vicinity of Beijing and Tianjin will be remarkably improved, with the forest cover reaching 19.44 percent, an average increase of 8.27 percent.

d) Key Shelterbelt Development Programs in Regions of the Three North and the Middle and Lower Reaches of the Yangtze River

The program is targeted to combating desertification in the three northern regions and other ecological degradation in other regions. It lasts for a long period of time with program phases. For example, the 4th phase of the "Three North" Shelterbelt Program has been initiated, with a focus on combating desertification. The 4th phase of the program covers 590 counties in 13 provinces in the three-northern regions. It was expected that 9.46 million ha of land will be afforested and 1.3 million ha of desertificated land brought under control during the period of 2001-2010. Upon completion of the program the net increase of forest cover in the program area will be as high as 1.84%, nearly 11.33 million ha of farmland put under shelter and 12.66 million ha of desertificated and degraded grassland protected and rehabilitated. Key shelterbelt development programs in the middle and lower reaches of the Yangtze River involve relevant areas in 31 provinces (autonomous regions or municipalities). It was expected that 18 million ha of land will be afforested, 7.33 million ha of low-efficiency shelterbelt improved and 37.33 million ha of existing forests properly managed and protected during the period of 2001-2010.

5.2 Urban Forestry and Urban Greening Will Draw More Funds for Urban Rural Interface Forest Rehabilitation

The rapid urbanization process in China with 1% annually has resulted in urban environmental degradation such as air pollution, water pollution, noise and heat island effect. All these issues are affecting people's physical and psychological health. Since the concept of urban forestry was introduced to China at the end of last century, theoretic research and practice of urban forestry have made significant progress and achieved remarkable results under the support of relevant agencies and governments at all levels. Forestry development strategic research and master planning for four provinces and four cities have been carried out, among which urban forestry development is one important strategy and component (Zhenhua Peng, 2003, 2006) .The urban forestry forum has been held annually in China since 2003 to provide a platform for city mayors, urban forestry scientists, urban forestry professionals to exchange new ideas and information about urban forest rehabilitation. During the past ten years, urban forestry and urban greening has been receiving wide attention by major big cities across China like Beijing, Shanghai, Chengdu, Changsha, and Shenyang.

5.3 Reforestation, Afforestation, and Tree Planting for Economic Purposes is Still the Priority Concern for the Local Forest Farmers and Local Government

The shift in forestry development from timber harvesting to ecological forestry should aim at full recovery of all ecological and environmental forest functions. However, the economic dependency of local farmers and local governments on forestry still is very high and this is especially the case in the collective forest region in Southern China (CAF, 2007). In addition, financial support for forest management and forest rehabilitation on the basis of forest ecosystem succession and natural regeneration is still pretty low compared with the investment for tree planting in national large-scale forestry programs.

6. Rehabilitation Techniques

In order to achieve the objectives of multiple-use forest management providing a wide range of benefits, forest rehabilitation must be carried out at both ecosystem and landscape level. The dual nature of forest rehabilitation in China for both ecological and socio-economic functions requires forest rehabilitation activities to be in line with regional objectives and local conditions. Major objectives and roles of forest rehabilitation differ from region to region because each region has its own specific environmental issues, physical conditions, and socio-economic context. Therefore, forest rehabilitation should be planned and designed according to local needs and major objectives of rehabilitation in a rational and scientific manner.

6.1 Forest Rehabilitation at the Landscape Level

Forest rehabilitation planning at this level is the first step to achieve the specific objectives. This process involves the analysis of landscape elements and accumulated effects in terms of biodiversity conservation, land improvement, impacts on water resources and water yield, vegetation corridors, connectivity, and ecosystem productivity. Social and economical analyses should also be performed during the process in order to ensure the success of a landscape restoration project. As most of the forest areas in China are spatially intermingled with other land uses, forest landscape rehabilitation planning is carried out as part of sustainable land use planning which integrates all kinds of forest lands with other land uses to achieve the collective optimum.

Various types of forest land such as protective forest, production forest, cash forest, and fuel-wood forest are then identified and delineated at the landscape and/or watershed level. Assessment models like Fragstats (McGarigal, K., and B. J. Marks. 1995), SWAT Soil and Water Assessment Tool (Gassman et al., 2007), and MIKE SHE (European Hydrological Modeling System)(Abbott, M.B. et al., 1986) are commonly used, in combination with remote sensing land use data processed through Geographical Information System (GIS) technology. The application of these tools greatly facilitates optimization of forest rehabilitation planning at the landscape level (Zhiqiang Zhang et al, 2007).

6.2 Ecosystem Design

This is the second critical step to develop sound forest rehabilitation programs. The native forest ecosystem is being assessed in terms of species composition, natural regeneration, succession stage, and disturbance regime. The results serve as the baseline for designing a forest rehabilitation program. Once the succession stage of the ecosystem has been identified as well as the ecosystem indexes analyzed, the intended structure and function of forest rehabilitation should be devised accordingly in terms of species composition, density, and tending measures.

6.3 Mountain Closure

A feasibility study of mountain closure techniques usually should be conducted at the very beginning of the rehabilitation process. Mountain closure is another technique widely used to facilitate the establishment of natural forest regeneration in different geographical regions of the country. If mountain closure based on ecological development assessment turns out to be a practical measure to rehabilitate degraded forests or forest land, the disturbance should be minimized. However, artificial closures and tending measures to promote the rehabilitation process are usually necessary in forests with multiple tree species, multi-layers, and uneven-aged structures.

6.4 Silvicultural Techniques

Successful silvicultural techniques should be adopted to promote the process of forest rehabilitation. Silvicultural techniques have been extensively studied in China since the very beginning of the first national afforestation program ("Three North" Shelterbelt Program) initiated in 1978. Research into these techniques has been carried out since the Sixth 5-Year Plan under various national research programs (Zhiqiang Zhang et al., 2003). Among these techniques site classification and the tree species/site-matching approach have successfully been applied in the "Three North" Region. Furthermore, many other scientific achievements related to tree species introduction and domestication, improvement, regulation of species composition, and stand density were also used. Basically, there are five steps for implementing silvicultural measures:

a) site classification of rehabilitation area usually is conducted by an integrated analysis of climate, soil, geomorphology, vegetation, and hydrology;

b) tree improvement techniques for specific site conditions through species selection, introduction, domestication, and improvement; micro-environment improvement for specific trees by means of site preparation and soil amelioration;

c) stand density control techniques by establishing density control graphs;

d) typical design of afforestation models for the establishment of mixed species forest ecosystems.

6.5 Tending Techniques

Tending operations are necessary to create a favorable growing environment for tree species, thus ensuring the quality of rehabilitation. These measures include introduction of new species, seeding, planting, site preparation, thinning, and the control of diseases and insect attacks. Numerous models for forest rehabilitation across the different geographical regions of China can be accessed at http://www.lknet.forestry.ac.cn/ld/home.htm (China Forestry Information Network).

6.6 Forest Rehabilitation for Soil Erosion Control

Loess Plateau of Middle Reach of Huanghe River:
Forest rehabilitation in the Loess Plateau located in the middle reach of the Huanghe River has been identified as suitable approach to deal with the dilemma of limited water resources and severe soil erosion. Water is a major limiting factor for forest rehabilitation to combat soil erosion in the region. High rainfall intensity during the intense summer storms associated with continental monsoon climate and low infiltration capacity of degraded soils in the region favors the surface runoff generation and high soil erosion rates (Zhang and Liu, 2005). This leads to serious soil erosion and drought due to the fragile ecological conditions and downstream environmental problems. Runoff mainly takes place from slope land and soil erosion from gullies.

Therefore, the spatial arrangement of different protective forests to be rehabilitated is usually implemented in accordance with the specific site quality and importance to reduce soil erosion of different landscape mosaics and fragmented landform units (e.g. slope, gully, headwater gully) within a small watershed. Physical structures such as check dams, slope revetment, bank revetment, and consolidation walls are integrated with biological measures in critical erosion control units (Ran et al., 2006).

Forest stand density is determined on the basis of the available water resources to promote the establishment and growth of the forest ecosystem. Forestry rehabilitation techniques to prevent water run-off developed by Wang et al.(2002) in the Loess Plateau region of China have been widely used in the region. After the completion of the hydrological analysis and estimation of the tree species-specific stand water use two types of intervention areas are delineated:

a) areas contributing to surface runoff during rainfall *and*

b) planting areas where runoff water is infiltrated and stored in the soil.

Mechanical compaction and application of non-polluting chemicals and moose on the surface runoff areas are effective water harvesting and evaporation reduction techniques. In the afforestation area trees are planted across slopes along contour lines (Wang et al., 2002). At the same time, measures for water conservation (e.g. mulching), water storage (ditching), and efficient use of stored water are necessary to ensure a continuous water supply for tree growth so as to achieve the intended forest rehabilitation objectives (Wang et al., 2002).

The farmland shelterbelt system consisting of road protection forests, slope bank protection forests, cash forest, intercropped forest, and scattered forest around villages should be established on flat terrain on the plateau. Forest rehabilitation for steep slope-lands over 25° generally is planted with multi-layered and uneven-aged stands or intercropped shelterbelts, farm crop, and grassland to effectively control soil erosion. Rehabilitation for the moderate slope-land less than 25° is usually developed into agro-forestry systems consisting of terrace bank forest, belt forest on terrace with slope interval, forest on contour ditch with slope interval. Protection forests on eroded gullies to promote sand filtering and bed fixation are usually established through mountain closure and afforestation approaches assisted by other physical structures for forest rehabilitation.

Hilly Area of Eastern "Three North" Region (Northeast China):
Severe sheet and gully erosion by concentrated surface flow derived from long slopes in this region have posted dramatic threats to the slope-land agricultural activities. It is very difficult to rehabilitate degraded forests in this region due to its severely degraded soil conditions. Therefore, forest rehabilitation for soil erosion control in this region includes physical structures and management practices promoting pastoral-forestry ecosystems on moderately steep slopes in hilly areas, soil bio-engineering measures for gully erosion control, sand filtering, bed fixation, and mountain closure for establishing multi-layer forest stands on stony mountain sites.

Stony Mountain Area of Taihang Mountain:
Soil erosion and floods take place frequently in this region. The reasons are steep slope gradients of the mountains, thin soil layers, rock outcrops, sparse vegetation coverage, and a climate that is characterized by frequent thunderstorms and torrential rainfall. Major methods for the spatial arrangement of soil and water conservation forest areas in this region include:

1) rational spatial arrangement of various forest types, multiple tree species composition, combination of tree, shrub, and grass in patches on slopes, *and*

2) establishment of agro-forestry systems in gullies and bank protection forests.

Upper and Middle Reaches of Changjiang River Basin:
The area is characterized by species richness, high annual precipitation, and extensive human activities causing frequent floods and soil erosion. Over time this has led to thin and poor soil layers. Because soil erosion takes place mainly on the slopes, the methods in this region include

1) establishment of soil and water conservation forests in accordance with dams, ponds, and rice fields to form an interwoven agro-forestry system on slopes,

2) protection forests arrangement in accordance with gully erosion control and hydraulic works and also basic farmland construction to achieve bank stabilization, bed fixation, and sand filtering.

6.7 Forest Rehabilitation for Water Resource Protection

In Northern China, typical forest rehabilitation measures include physical structures for water resources collection and rational temporal distribution, structural and biological measures including soil amelioration, runoff collection, water-conserving irrigation, tree species selection, moderate afforestation, stand density control on the basis of rational spatial arrangement. In the basin of the Changjiang River, tree species selection, composition, and density control are major methods aiming at deriving ecological, economic, and social benefits from establishing soil and water conservation forests.

Forest rehabilitation for water resources protection is usually conducted by integrated analysis of storm flow, low flow, ground water, water quality, and water environmental situation of the watershed on the basis of forest hydrological principles. Water resources conservation forests system construction and sustainable management at watershed scale is targeted to achieve regulation, water saving, and water purification target of the system. The methods include

1) spatial layout of a water resource conservation forest system at basin scale characterized by various forest types, multiple tree species, low water consumption, and high water regulation efficiency,

2) stable stand structure design and regulation methods such as tree species selection, species combination, stand density control on the basis of low water consumption, high efficient pollution control, and runoff regulation,

3) afforestation and management methods for water resource conservation forest such as site preparation, planting point arrangement, tending and regeneration.

In addition, methods for oriented recovery of existing water resources conservation vegetation include mainly:

1) low water consumption, low pollution, and high efficient runoff regulation oriented natural vegetation recovery;

2) poor quality, low efficient water resources conservation forests reformulation.

For the reservoir catchment, it includes:

1) spatial layout for water resource conservation forest system targeting low water consumption, low pollution, high runoff regulation efficiency, and reservoir bank stabilization,

2) stable stand or belt structure design and regulation methods,

3) afforestation methods in the form of stand or belt for bank protection, sedimentation control of reservoir, *and*

4) oriented natural vegetation recovery aiming at bank protection and sedimentation control of the reservoir.

6.8 Forest Rehabilitation through Agroforestry Systems

Numerous agro-forestry management techniques in different regions of China have been developed as traditional land use and land management evolves. Agro-forestry ecosystem establishment has contributed a lot to forest rehabilitation in this one of the most populated countries in the world. Traditionally, there are many different types of agro-forestry system in China. Agro-forestry system, pastoral-forestry system, agro-pastoral-forestry system, forestry-fishery system, agro-fishery-forestry system, agro-Chinese medicine herb forestry system, Chinese medicine herb forestry system are all common practices in most of China. The management of the competition for light, water, and nutrients between forest trees and other crops is critical for outperforming sole cropping system in terms of yield, ecological services, and economic incomes. The trees and the other crops may compete for light, water, and nutrients or have complementary needs. When the interactions between the trees and crops are managed well, agroforestry systems, traditional or modern, can outperform sole cropping systems.

6.9 Forest Rehabilitation Techniques on Poor Sites

Poor sites can be found on calcium carbonate land, dry and poor mountains, saline-alkali land, degraded rangeland, dry and hot river bed areas, limestone mountains, and wasteland in ex-mining areas. It is hard to rehabilitate this kind of degraded land.

Drought resistance and water-saving tree planting techniques include:

1) planting techniques like runoff forestry, soil moisture keeping, application of soil moisture keeper, selection of drought resistant species, seedling specifications, and seasonal planting.

2) highly effective use of water sources and management techniques for stable plant community and its restoration;

Tree planting techniques in dry and poor rocky mountains include:

1) silvicultural techniques in rocky mountains with thin soil layers,

3) Artificial promotion techniques for plant restoration, such as site preparation, soil moisture keeping, water harvesting and water-seepage proof techniques.

Tree Planting Techniques in Saline-Alkali Land
Saline-alkali resistant species selection and its planting techniques, saline-alkali soil melioration techniques by chemical and biological technology, and other integrated engineering techniques to regulate groundwater tables.

Tree Planting Techniques in Dry-Hot River Valley
Water harvesting and water-saving techniques, soil preparation, selection of drought tolerant species and related shelterbelt planting techniques, tree planting techniques in dry-hot riverbeds.

Tree Planting Techniques in Drought River Valley
Tree and grass species selection, anti-drought soil preparation, water harvesting and moisture keeping, seedling specifications, planting seasons, etc.

7. Planted Species

The nature of a diversified geographical situation, climate, hydrology, geology, pedology, fauna, and flora in China requires the most diversified forest rehabilitation approach. Most commonly used tree species for forest rehabilitation across China are listed in Annex 1 (CFSDC, http://www.lknet.forestry.ac.cn/ld/home.htm).

8. Case Study – Forest Rehabilitation in the Limestone Area of Southwest

Located in Guizhou Province, Southwest China, the limestone area is a fragile ecosystem. Forest rehabilitation in this ecosystem is a difficult undertaking after heavy disturbances by human activities. These have led to soil erosion causing frequent rock outcrops covered by thin and discontinuous soil layers with low water holding capacity. Research suggests that severe human disturbances could stop the reverse succession of secondary vegetation in this area. Forest rehabilitation techniques in this region have been developed on the basis of natural vegetation succession principles assisted with some artificial measures to expedite the recovery process.

8.1 Succession Stage of Vegetation Ecosystem

The natural succession stages in the limestone area can be grouped into herbaceous stage, shrub and herb shrub stage, shrub stage, forest stage, and climax stage. The ecological indicators for different stages are listed in Table 3 (Zhu Shouqian, 2003).

8.2 Classification of Rehabilitation Types

Grassland with Scattered Shrub: This type of landscape is the result of severe damage to the original forest vegetation. After cutting of trees, grazing, or burning, the vegetation is dominated by grass and randomly scattered with tree remnants and invasive shrub species. This is the transitional stage from grassland to scrub. Rock exposure percentage of the land is as high as 40% to 80%. Thin, infertile, stony, and dry soil layers are between 9 and 42 cm deep. The stone and gravel content of soil is about 60%.

Scrub: Scrub is a typical secondary vegetation and widely distributed in this region after intensive human disturbances and destruction of the native forest ecosystem. The majority of the scrub vegetation is located on sun-facing slopes with higher rock outcrop from 40% up to 75%. Soil depth is only about 9 to 40 cm with very high stone and gravel content. The main species are *Pyracantha fortuneana, Viburnum, Myrsine africana, and Rosa cymosa.* These species generally have strong capability for seed germination, sprouts and tiller ability, and grow in multi-clusters.

Table 3: ***Characteristics of Vegetation Community in the Different Succession Stages***

Biometric Index	Herbaceous	Grass and Shrub	Shrub	Forest	Climax
Height (m)	0.6	1.4	2.1	5.2	9.6
DBH/Diameter of herbal and shrub vegetation (cm)	0.4	1.3	1.8	7.2	10.3
Density (Stem/hm²)	12938	59927	94042	3410	3170
Coverage %	35	46	75	77	79
Biomass (t/hm)	3.7501	4.3933	13.3726	35.0048	81.8084
Main species composition	*Pteridium aquilinum* var. *latisculum*, *Miscanthus floridulus* *Cyperus* sp.	*Pyracantha fortuneana, Rubus palmatus, Rosa cymosa*	*Viburnum, Myrsine africana, Rhamunus parvifolia, Zanthosylum planispinum* Sieb. *et Zucc*	*Itea ilicifolia, Platycarya longipes, Quercus fabric, Ligustrum lucidum, Ilex chinenis* Sims	*Carpinus pubescens, Cladrastis platycarpa, Photinia davidsoniae, Celtis sinensis*

Low Value Forest: There are two types of low value forests, namely broad-leaved forests and coniferous forests. The low value broad-leaved forest evolved after the primary forest had been logged and developed by asexual regeneration primarily from tree roots, cutting pile germination and sprouts. This type of forest covers the lower parts of slopes with slightly better site conditions, mainly smaller rock exposure percentage. The soil layer is deeper than that of the scrub stage and measures over 30 cm. Species composition is complex and dominated by *Quercus acutissima*, *Quercus fabric, Carpinus pubescens, Litsea pungens, Betula luminifera, Lindera communis, and Populus adenopoda.*

Abandoned Agriculture Land: Abandoned agriculture land is distributed in the middle and upper slope. The severe soil erosion after the cultivation of natural forest land into agriculture leads to degradation of the land quality and marginal agriculture. There are no original vegetation species and propagation material. Therefore, the natural rehabilitation of vegetation on abandoned agricultural land depends on the invasion of ambient species.

Abandoned Mining land: Bad site conditions after severe soil degradation and vegetation destruction due to mining practices are characterized by high stone content in the soil profiles. Although soil conditions in the vicinity of mining pits are deeper, the recovery of vegetation in this kind of land depends on the invasion of alien species.

8.3 Technical Measures for Vegetation Rehabilitation

Seed Sowing and Seedling Replanting to Increase the Species Abundance: Heterogeneous and fragmented landscapes with some open areas caused by severe degradation and poor site conditions show very slow regeneration processes of natural vegetation. These sites include grassland with scattered shrub, scrub, and abandoned mining land, if the mountain closure is the only measure adopted for rehabilitation. Therefore, artificial sowing and replanting to increase species diversity and abundance is a necessary step to promote the rehabilitation process. Pioneer species like *Betula luminifera* and *Itea ilicifolia* can be selected to recover these poor site conditions. These species are viable, stress resistant, and can easily be regenerated. Surveys showed that 386 seedlings per square meter can be regenerated from natural *seeding of betula luminifera* and 519 seedlings per 100 m^2 for *Itea ilicifoli.*

Coniferous tree species such as *Fokienia hodginsii (Dunn) Henry et Thomas* and *Cupressus pinus armandi* can be used in sowing and replanting to rehabilitate forests on abandoned agriculture lands with better site conditions. The introduction of broadleaved tree species to low value forests dominated by *Pinus massoniana Lamb* increases the stability and resistance of the rehabilitated mixed stands.

Tending measures to promote natural regeneration: Grassland with scattered shrubs, scrub and low value coniferous forests with rich species composition generally can be rehabilitated by natural regeneration. However, in order to promote asexual propagation and natural forest regeneration, tending measures such as soil loosen, stem removal, branch removal may be adopted to assist this process.

Regulating species composition and density: Some low value forests and scrubs have complex species composition, high density, uneven distribution, and low growth rates. Species composition and density need to be regulated for those ecosystems in order to accelerate its rehabilitation. Traditional forest management practices include selective cutting and thinning to remove inferiors and retain superiors and adequate stocking density. In this approach, species of low economic value and bad growth trends will be removed while those species of rapid growth, large quantity, high value and the good future prospects will be retained.

For instance, cutting competing vines, bush, and weed species within *Quercus* and *Betula luminifera* dominated broad-leaved forests can promote the growth and productivity of *Betula luminifera*, *Quercus fabric,* and *Populus adenopoda* which are retained for future harvesting and protection. A field study indicated that the annual diameter growth and height for these types of species composition under a given stand density increased by 63.4% and 34.1%, respectively, compared with the untreated control plots.

The summary of technical measures to support mountain closure for forest rehabilitation in the limestone area of Guizhou Province is given in Table 4.

Table 4: ***Technical Measures Supporting Mountain Closure to Expedite Forest Rehabilitation***

Mountain Closure Type	Technical Measures	Time for Rehabilitaion
Sparce shrub grassland type	Sowing, replanting, increase provenance	Over 10 ha
Bush type	1) Sowing, replanting 2) Artificial promoting of regeneration 3) Species composition adjustment	5-10 ha
Low-value high forest type	1) Species composition adjustment and density control 2) Replanting	5 a
Abandoned agricultural land	Sowing, replanting	5-10 a
Abandoned mining land	Sowing, replanting	5-10 a

9. Research, Extension and Education Capacity

There are many universities and research institutes conducting forest rehabilitation research and education in China. Forestry universities such as Beijing Forestry University, Northeast Forestry University, Nanjing Forestry University, Central South Forestry University of Science and Technology, Northwest Sci. & Tech. University of Agriculture and Forestry; Zhejiang Forestry College and almost every agriculture university have their own forestry faculty.

Research institutes include Chinese Academy of Forestry and 32 provincial academies of forestry. There are systematic technical training centers and technical extension centers at national, provincial, regional, and county level across the country.

The structure of the National Education, Research & Extension in Forest Rehabilitation is illustrated in Figure 2.

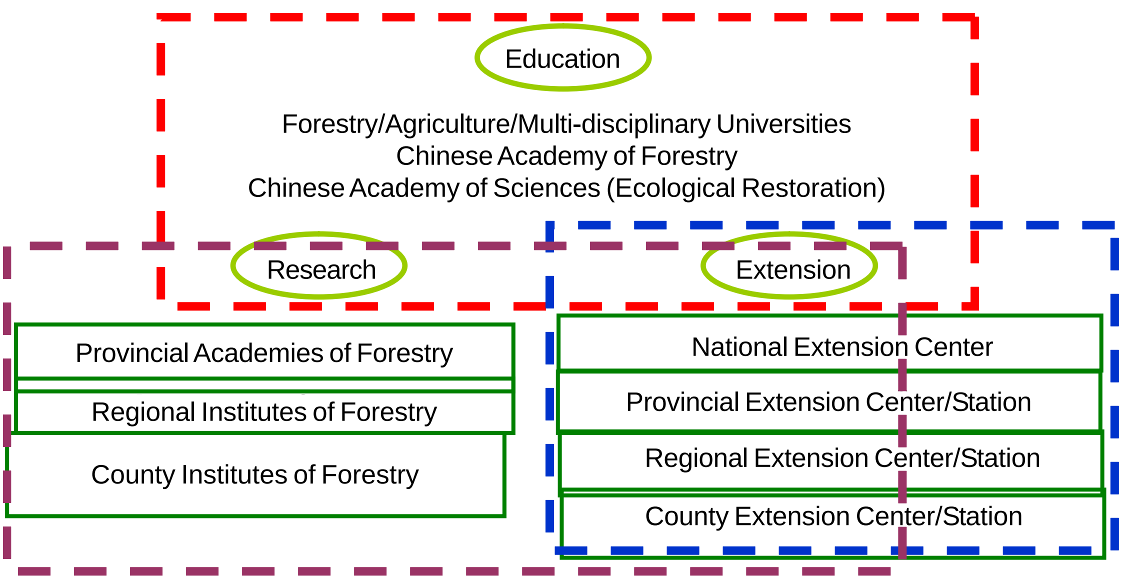

Figure 2: ***Institutional Structure of Forest Rehabilitation Education, Research, and Extension in Mainland China***

There are a large number of graduates from forestry universities, colleges, and vocational schools every year in Mainland China. Figure 3 shows the annual number of graduates from forestry universities and forestry vocational schools from 1991 to 2006. Those graduates obtained their vocational certificates, bachelor degrees, master degrees, and Ph.D. degrees. (CFSDC, http://www.lknet.ac.cn/ly/).

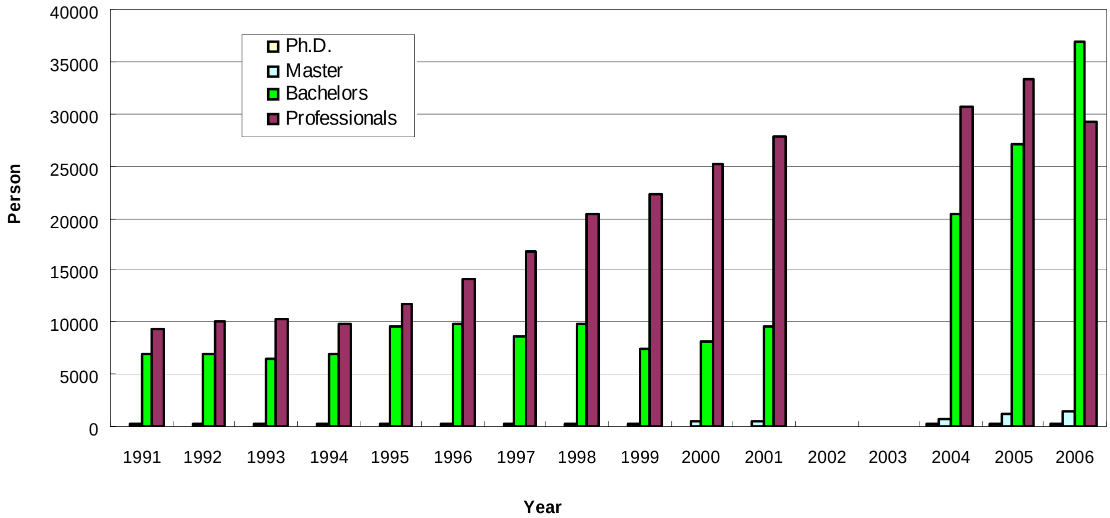

Figure 3: ***Graduates from Forestry Universities/Vocational Schools***

The total number of forest research institutions in China from 1996 to 2003 is shown in Figure 4 (CFSDC, http://www.lknet.ac.cn/ly/).

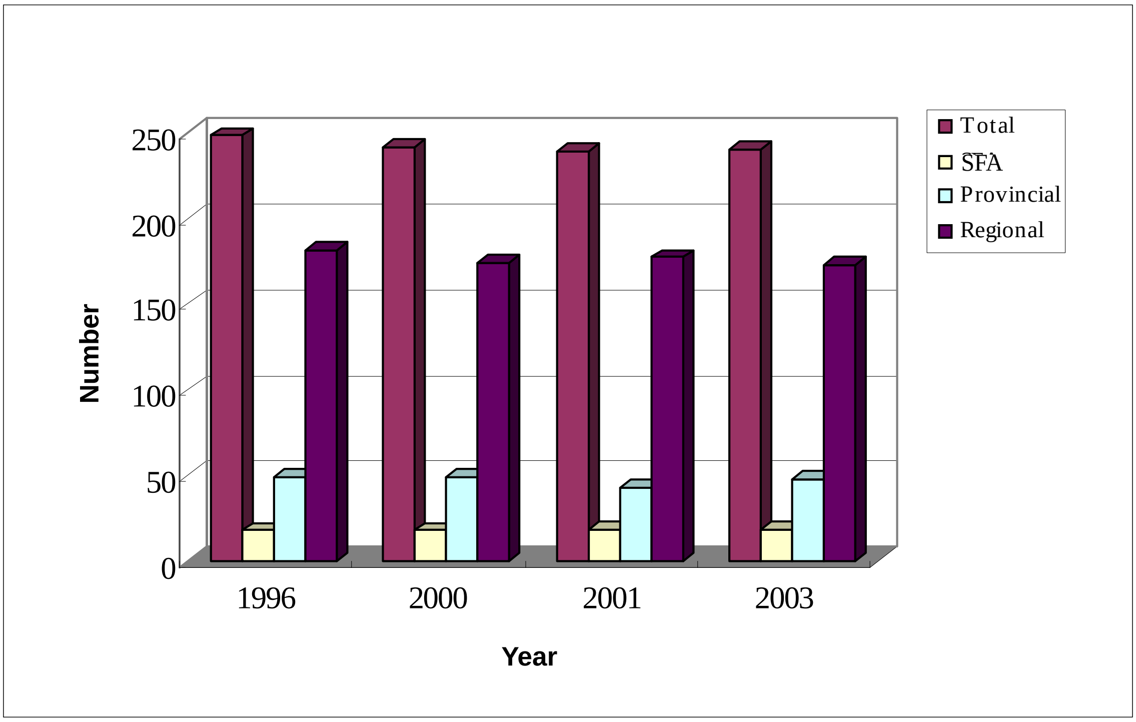

Figure 4: ***Number of Forest Research Institutions in China 1996-2003***

The total number of faculty and staff in forest research institutions in Mainland China from 1996 to 2003 is shown in Figure 5 (CFSDC, http://www.lknet.ac.cn/ly/).

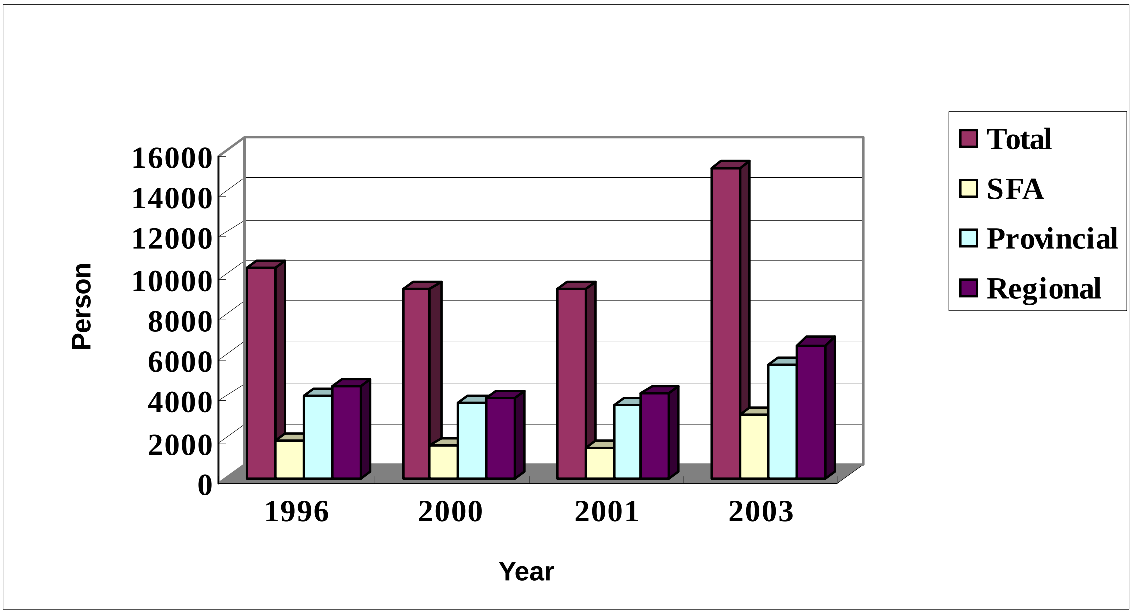

Figure 5: ***Faculty and Staff in Forest Research Institutions in China 1996-2003***

To increase the capacity of forest research, the Department of Science and Technology of the State Forestry Administration issued a strategic plan for forest research. The number of long-term experimental stations, engineering centers, and key laboratories to be established over the next ten years are listed in Figure 6 (CFSDC, http://www.lknet.ac.cn/ly/). This will greatly increase the national buildup of research & education capacity for forest rehabilitation.

Forest rehabilitation research funding resources usually come from central government agencies such as the Ministry of Science & Technology, State Forestry Administration, National Science Foundation of China, Chinese Academy of Sciences, Ministry of Education, Ministry of Water Resources, Ministry of Land Resources, Ministry of Transportation, Ministry of Railway and provincial governments, international organizations and foreign governments, and the private sector.

The current education and research programs are sufficient to cater for the needs of the forest sector for forest rehabilitation in China.

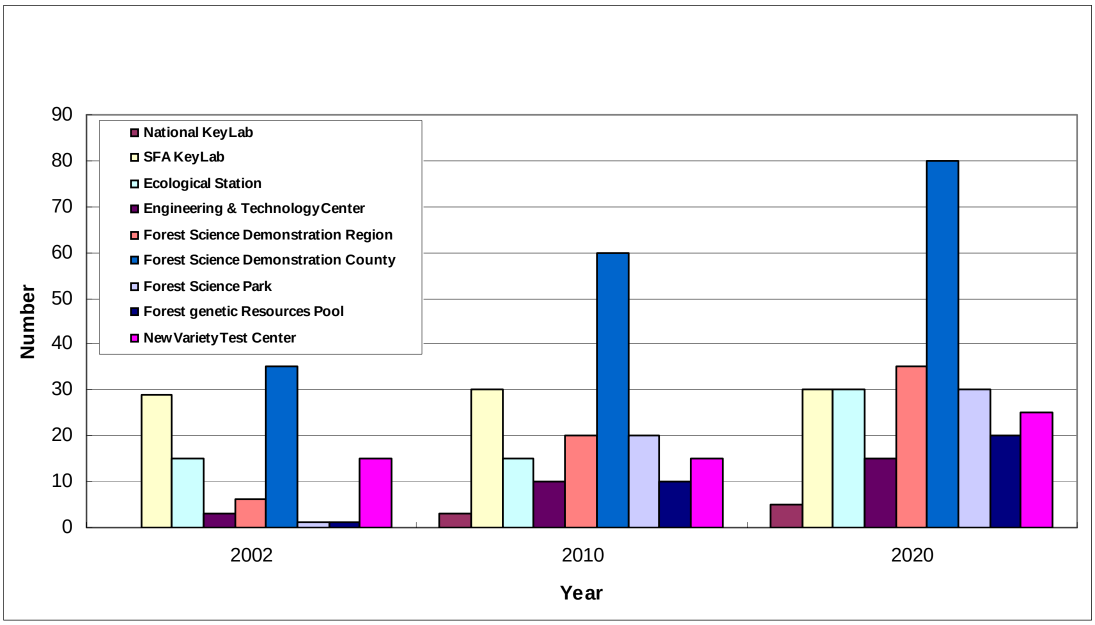

Figure 6: ***Research Facilities Planned by SFA***

10. Conclusions and Recommendations: Future Policies

The Chinese forest rehabilitation programs implemented in the recent past made a very significant contribution to the increase in forest coverage, soil erosion control, carbon sequestration, clean water supply, healthy hydrological environment, wood supply, biodiversity protection.

The successful effort of large scale afforestation in China indicates the government's commitment to social and private investment, strong governance and regulation policies. However, the quality of established forests is still rather low to maintain their ecological and environmental services and productivity. The shift from large-scale tree planting to sustainable management of forest resources and forest landscape rehabilitation will drive the forestry investment from government afforestation to forest rehabilitation.

Essential measures to ensure continuous improvement of Chinese forest resources and forest functions include logging quotas according to the forest ecosystem productivity, reduction in the forest tax for commercial forests, increase in the compensation for ecological forests, reform of the forest tenure arrangements for collective forests, increase in the government budget for sustainable forest management, and formulation of sustainable forest management plans. These support measures are even more important given China's fast growing economy and the associated threats to the health and survival of its environment.

10.1 The Shift of National Forestry Programs from Afforestation to Forest Rehabilitation at Ecosystem and Landscape Scales Will Play a Critical Role

For most provinces and municipalities, forest land has been afforested and forest coverage is growing. However, the quality of forests in most parts of the country is still low in comparison with other countries. The proportion of pure forest plantations is very high which causes critical problems of forest insects and diseases. Forestry development of China has shifted away from the establishment of artificial timber forests to ecological rehabilitation of natural forests and improvement of a large proportion of forest plantations. The dual nature of forestry, i.e. its focus on economic and social benefits at the same time, has become more and more important. Restrictions on logging in natural forests, focus on plantations for timber production, provision of public benefits in state-owned forests and the conversion of croplands to forests are major components of this shift of focus. In terms of institutional reforms and improving the forest bureaucracy, China has also achieved some major changes and has greatly increased its investment into forest restoration. For example, in 2000 the total investment in improved forest management was equivalent to the entire investment in this area in the 50 years prior to 2000.

Forest rehabilitation and restoration need to be carried out from stand-level across the landscape scale. The relevant policy should be devised to meet this shift of Chinese forestry development.

10.2 Cross-sector Coordination of Agriculture, Forestry, Water Resources, and Infrastructure Should be Strengthened

Most of the major policy issues in the forest sector are multi-sectoral and require coordination with other sector policies. For example, sectors closely connected with forestry are agriculture, land use, transportation, rural development, and technology.

10.3 Developing Feasible Ecological Compensation Policy is one of the Key Instruments to Facilitate Forest Rehabilitation

Government departments at various levels are still the main buyers of ecological services in China and provide the majority of all compensation payments. Although there is currently a policy for ecological compensation in place, much work remains to be done to broaden and strengthen this policy.

The compensation payments are currently made along uniform and undifferentiated standards. To improve implementation, a competitive compensation mechanism that can be adapted to local situations needs to be developed. Such flexible implementation schemes should function on the basis of government-set standards and indicators and allow for competitive bidding in order to adequately represent the opportunity cost of different locations.

10.4 The Forest Tenure Reform in China Should be Implemented with Full Integration of Sustainable Forest Management Planning

Local governments in collective forest regions are very keen to develop their forestry industries as the financial revenue dependence on forestry is still very high. Therefore, the protection of forest resources while maintaining the economic growth is still a challenge for forest rehabilitation in China. The tenure reform of collective forests aiming at liberating the forestry markets needs to be balanced by adherence to strictly sustainable forest management measures in order to maintain the ecological functions of the forest ecosystem.

10.5 Implementation of New Technologies and Policies to Protect, Increase, and Manage Biodiversity for Forest Plantation Across the Country

The increase of forest resources in China is largely the result of large scale afforestation. Therefore, forest quality in terms of growth rate, biodiversity, forest land productivity is not very high. Future rehabilitation and restoration efforts will improve this situation to a great extent.

10.6 Ecosystem, Landscape, and Regional Evaluation and Monitoring of Forest Rehabilitation and Information and Data Sharing Needs to be Strengthened

Information and data sharing for forest rehabilitation in China is essential for supporting rehabilitation and restoration policies at the regional level. This should include a consistent system of impact evaluation of forest rehabilitation measures including assessment of benefits and a monitoring and information management network specifically adapted for different geographical regions, comprising monitoring methods, data collection and processes. On the basis of this information, decision-support tools should be developed for the design, monitoring, construction, impact evaluation, and management of forest rehabilitation and restoration.

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Annex 1: *Most Commonly Planted Tree Species for Forest Rehabilitation in China*

No.	***Scientific Name (Latin Name)***
1	*Larix sibirica Ledeb.*
2	*Pinus sibirica (Loud.) Mayr*
3	*Abies sibirica Ledeb*
4	*Picea obovata Ledeb.*
5	*Betula pendula Roth*
6	*Populus davidiana*
7	*Lonicera*
8	*Rosa*
9	*Betula*
10	*Picea asperata Mast. [Picea asperata Mast. var. aurantiaca (Mast.) Boom-P. asperata Mast. var. heterolepis (Mast.) Cheng]*
11	*Populus euphralica Oliv*
12	*Salix sino-purpurea C. Wang et Ch. Y. Yang*
13	*Populus simonii Carr.*
14	*Salix matsudana Koidz.*
15	*Salix gordejevii Chang et Skv. [Salix flavida Chang et Skv.]*
16	*Lilium pumilum DC.*
17	*Hedysarum scoparium Fisch. et Mey. [Corethrodendron scoparium Basiner et Fisch.]*
18	*Rhamnus davurica Pall.*
19	*Rosa xanthina Lindl.*
20	*Clerodendrum cyrtophyllum Turcz.*
21	*Larix principis-rupprechtii Mayr*
22	*Pinus tabulaeformis Carr.*
23	*Prunus armeniaca var. ansu Maxim. [Prunus ansu Kom.]*
24	*Betula platyphylla Suk.*
25	*Populus davidiana Dode [Populus tremula L. var. davidiana (Dode) Schneid.]*
26	*Quercus liaotungensis Koidz.*
27	*Stipa bungeana Trin.*
28	*Stipa breviflora Griseb.*
29	*Populus × xiaozuanica W. Y. Hsu et Liang [Populussirnonii Carr. × P. nigra L. var. italica (Moench) Koehne]*
30	*Populus × xiaohei T. S. Huang et Y. Liang [Populus simonii Carr. × P. nigra L.]*
31	*Lespedeza bicolor Turcz.*
32	*Amorpha fruticosa L.*
33	*Picea koraiensis Nakai*
34	*Pinus massoniana Lamb.*
35	*Pinus taiwanensis Hayata [Pinus hwangshanensis Hsia]*
36	*Cyclobalanopsis glauca (Thunb.) Oerst. [Quercus glauca Thunb. -Q. longipeg Hu]*
37	*Cunninghamia lanceolata (Lamb.) Hook.*
38	*Phyllostachys edulis (Carr.) H. de Lehaie [Phyllostachys pubescens Mazel ex H. de Lehaie]*
39	*Schima superba Gardn. et Champ.*
40	*Choerospondi asaxillaris (Roxb.) Burtt et Hill [Spondias axillaris Roxb.]*
41	*Pinus taiwanensis Hayata [Pinus hwangshanensis Hsia]*
42	*Hemarthria compressa(L.f.)R.*
43	*Dendrocalamus membrana-ceus Munro*
44	*Fokienia hodginsii (Dunn) Henry et Thomas*
45	*Camellia oleifera Abel*
46	*Tsuga chinensis (Franch.) Pritz.*
47	*Vernicia fordii (Hemsl.) Airy-Shaw [Aleurites fordii Hemsl.]*
48	*Bambusa textilis McClure*
49	*Cunninghamia lanceolata (Lamb.) Hook.*
50	*Potentilla fruticosa L. [Dasiphora fruticosa (L.) Rydb.]*
51	*Abies fabri (Mast.) Craib*
52	*Salix gordejevii Chang et Skv. [Salix flavida Chang et Skv.]*
53	*Caragana microphylla Lam.*

54 *Cornus walteri Wanger.*
55 *Malus baccata (L.) Borkh.*
56 *Crataegus pinnatifida Bge.*
57 *Prunus davidiana (Carr.) Franch.*
58 *Pinus armandi Franch.*
59 *Myrica rubra Sieb. et Zucc.*
60 *Acacia richii A. Gray [Acacia confusa Merr.]*
61 *Pavetta arenosa Lour.*
62 *Cratoxylum cochinchinense (Lour.) Blume [Cratoxylum ligustrinum (Spach) Blume-Ancistrolobus ligustrinus Spach]*
63 *Endospermum chinense Benth.*
64 *Betula davurica Pall.*
65 *Betula microphylla Bge.*
66 *Alnus mandshurica (Callier) Hand. -Mzt.*
67 *Rom macrophylla*
68 *Linnaea borealis L.*
69 *Populus × xiaohei T. S. Huang et Y. Liang [Populus simonii Carr. × P. nigra L.]*
70 *Picea balfouriana Rehd. et Wils. [Picea likiangensis (Franch.) Pritz. var. balfouriana (Rehd. et Wils.) Hillier ex Slavin-P. sikangensis Cheng]*
71 *Picea purpurea Mast.*
72 *Betula albo-sinensis Burk.*
73 *Populus cathayana Rehd.*
74 *Sabina tibetiea Kom. [Juniperus tibetica Kom.]*
75 *Picea Dietr.*
76 *Abies Mill.*
77 *Quercus semicarpifolia Smith [Quercus obtusifolia Don]*
78 *Zanthoxylum bungeanum Maxim. [Zanthoacylum bungei Pl. -Z. usitatum Diels-Z. imperforatum Reede ret Cheo]*
79 *Sophora davidii (Franch.) Pavilini [Sophora moocroftiana var. davidii Franch. -S. viciifolia Hance]*
80 *Coriaria sinica Maxim.*
81 *Vitex negundo L.*
82 *Pyracantha fortuneana (Maxim.) Li*
83 *Cotinus coggygria Scop. var. cinerea Engl.*
84 *Pinus densata Mast.*
85 *Pinus yunnanensis Franch.*
86 *Clethra fabri Hance [Clethra annamensis P. Dop-C. tonkinensis P. Dop-C. liangii Li]*
87 *Casuarina equisetifolia L.*
88 *Ailanthus altissima (Mill.) Swingle [Toxicodendron altissima Mill. -Ailanthus glandulosa Desf.]*
89 *Berberis L.*
90 *Quercus pannosa Hand. -Mzt. [Quercus ilex L. var. rufescens Franch.]*
91 *Abies delavayi Franch.*
92 *Larix potaninii Batal. var. macrocarpa Law*
93 *Castanopsis delavayi Franch. [Castanopsis tsai Hu]*
94 *Lithocarpus variolosus (Fr.) Chun [Quercus variolosa Fr. -Lithocarpus hui A. Camus-L. chienchuanensis Hu]*
95 *Abies forrestii C. C. Rogers [Abies delavayi Franch. var. forresfii (C. C. Rogers) A. B. Jackson]*
96 *Picea likiangensis (Franch.) Pritz.*
97 *Abies georgei Orr [Abies delauayi Franch var. georgei (Orr) Melville]*
98 *Imperata cylindrica*
99 *Bombax malabaricum DC. [Salmalia malabarica (DC.) Schott-Gossampinus malabarica Merr.]*
100 *Leucaena leucocephala (Lam.) De Wit cv. 'Salvador'[Leucaena salvadorensis Standley]*
101 *Leucaena leucocephala (Lam.) De Wit [Leucaena glauca (L.) Benth.]*
102 *Cajanus cajan (L.) Millsp. [Cajanus flavuc DC.]*
103 *Acacia farnesiana (L.) Willd.*
104 *Cassia siamea Lam.*
105 *Ricinus communis L.*
106 *Larix kaempferi (Lamb.) Carr. [Larix leptolepis (Sieb. et Zucc.) Gord.]*

107 *Litsea pungens Hemsl.*
110 *Tamarix chinensis*
111 *Haloxylon ammodendron*
112 *Caragana korshinskii*
113 *Populus gansuensis*
115 *Ulmus laevis*
116 *Stipa capillata*
117 *Juniperus rigida*
119 *Amygdalus mongolica*
120 *Platycladus orientalis*
121 *Juniperus rigida*
122 *Ostryopsis davidiana*
123 *Spiraea salicifolia var.salicifolia*
124 *Thymus mongolicus*
125 *Leymus chinensis*
126 *Pinus sylvestris var.mongolica*
127 *Pinus densiflora*
129 *Fraxinus rhynchophylla*
130 *Acer mono*
131 *Syringa oblata var.alba*
132 *Quercus acutissima*
133 *Platycarya strobilacea*
134 *Quercus variabilis*
135 *Vitex negundo var.cannabifolia*
136 *Liquidambar formosana*
137 *Pinus elliottii*
138 *Toona sinensis*
139 *Lindera aggregata*
140 *Gardenia jasminoides*
143 *Eragrostis pilosa*
145 *Sassafras tzumu*
151 *Castanopsis hystrix*
152 *Cinnamomum philippinense*
153 *Rhododendron*
156 *Kobresia*
158 *Elaeagnus angustifolia*
159 *Salix psammophila*
160 *Calligonum mongolicum*
162 *Betula*
163 *Tilia tuan*
164 *Sorbus pohuashanensis*
166 *Carpinus turczaninowii*
167 *Staphylea holocarpa*
171 *Alnus cremastogyne*
172 *Robinia pseudoacacia*
175 *Liquidambar formosana*
177 *Rhus chinensis*
178 *Pinus kesiya var.langbianensis*
181 *Acacia auriculiformis*
182 *Rhodomyrtus tomentosa*
184 *Quercus mongolica*
185 *Rhododendron dauricum*
186 *Salix floderusii*
187 *Empetrum nigrum*
188 *Ledum palustre*
189 *Buxus sinica var.vacciniifolia*
191 *Trientalis europaea*
192 *Deyeuxia turczaninowii*
194 *Puccinellia chinampoensis*
195 *Betula utilis*

198 *Euptelea pleiospermum*
199 *Eucommia ulmoides*
201 *Rhodiola rosea var.rosea*
203 *Gentiana macrophylla*
204 *Notopterygium incisum*
207 *Phyllanthus emblica*
208 *Opuntia stricta var.dillenii*
212 *Dodonaea viscosa*
213 *Macroptilium lathyroides*
214 *Vetiveria zizanioides*
216 *Ziziphus mauritiana*

Establishment of Chinese Willow (*Salix matsudana*) Plantation to Combat Desertification in Inner Mongolia, China. **–** A Project Supported by Yuhan-Kimberly of Korea.

Forest Rehabilitation in the Democratic People's Republic of Korea

Ho Sang Kang[1], Joon Hwan Shin[2], Don Koo Lee[3] and Samantha Berdej[4]

1. General Information

1.1 Geographic Information and Topography

The Democratic People's Republic of Korea (DPR Korea) is situated in the eastern part of the Asian continent and is neighbored by China in the west and north, and by Russia in the northeast. The DPR Korea is predominately made up of mountainous terrain (approx. 80% of the total land area), being characterized by steep slopes, deep valleys and numerous rivers and brooklets. There are approximately 100 natural lakes, 38 major rivers, 10,208 streams and brooklets, and 1,700 artificial reservoirs. The total length of all streams amounts to 64,855 km (UNCCD 2006). The area of water bodies including lakes, reservoirs and streams covers 6% of the total land area. The average elevation of the country is 586 m above sea level. The topography generally exhibits a high variation in mountainous relief with a maximum elevation difference of 1,500 m with the majority of the area made up of slopes. There are diverse soil types with distinct horizontal and vertical distribution of geological zones. The bedrock consists largely of granite, granite-gneiss, limestone and slate (or argillite).

Four distinct climatic seasons exist with an annual mean temperature of 8.9° C with a variation between 0° C ~ 10° C depending on the region. The average precipitation ranges from 1,000 ~ 1,200 mm per annum. Spring (from April to June) is dry while in summer wet weather conditions are common. In the past, precipitation occurring in the rainy season (July and August) accounted for more than half of the annual precipitation. However, more recent trends indicate a less abrupt change in precipitation levels between the dry and wet seasons.

1.2 Population

In 2004, the population of the DPR Korea was estimated at 23.612 million (UNCCD 2006). The annual rate of population growth is approximately one percent. According to population statistics taken by the United Nations Convention to Combat Desertification (UNCCD) in 2002, the 'blue and white collars' account for 67.8% of the population while cooperative farmers account for 29.1% of the total population. All people have access to free medical care and a free obligatory education system, thus illiteracy is non-existent. Additionally, pension- and subsidiary systems provide support for men of merit, aged and disabled ones.

1.3 Economic Situation

As a socialist industrial state, the DPR Korea is developing the national economy by relying largely on its own resources and technologies. The economic activities of the country can be subdivided into three sectors:

1) line industries - including iron steel, chemical, cement, manufacturing, electricity, electronics, fishery and construction industries;
2) service sectors such as transport, communication, trade and finance businesses; *and*
3) agriculture.

In 2000, the GDP was approximately US$ 10.608 billion; a notable decrease from US$ 20.875 billion in 1990 (UNCCD 2006). The country has limited arable lands, but the government continues to pursue a policy of meeting food demand with self-production.

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1.4 Natural Resources

The DPR Korea has about 9 million ha of forestland or 72.5% of the total land area (UNCCD 2006). The forests are largely concentrated in the northern inland regions with high mountains; whereas the western coastal areas with low-elevation flat lands have fewer forests. The average standing tree volume is 47.5 m^3 per ha for natural forests and 57.3 m^3 per ha in timber plantations. The forest is dominated by three main types: broadleaved forest, coniferous forest and mixed forest (UNDP 2003). Among the total vascular bundle plant species present in the country, 315 species or 10% are endemic (UNDP Global Environmental Facility 1998).

According to the assessment of the UNCCD (2006), in 2002 the species composition of forest land was as follows:

- Coniferous(evergreen) forests: 41.9%
- Deciduous forests: 35.6%
- Coniferous-deciduous mixed forests: 22.5%

In a similar evaluation in 2002 (UNCCD 2006) forestlands were classified into the following seven land use categories:

Land Use Category	*Area (ha)*
• Protected area/conservation forests	953,500
• Industrial timber production forests	5,090,200
• Forests with economic values	1,181,600
• Firewood forests	398,800
• Grasslands	204,600
• Non-woody forestland	876,800
• Non-forested land	407,300

1.5 Environmental Issues

Similar to other developing countries, the environmental issues in DPR Korea are directly correlated with population growth and socio-economic development. Overexploitation of natural resources and environmental pollution has triggered major environmental concerns. The chief issues related to the environment in the DPR Korea are as follows:

a) Deforestation and Land Conversion

Although mountainous forests cover approximately 80% of the country's territory, the government's push for self-reliance **–** be it for food production or livelihood **–** continually threatens forest health. The conversion of forested land for the purpose of agriculture is one of the leading factors responsible for deforestation. DPR Korea comprises approximately 2,042,100 ha of agricultural land (1,839,000 ha of which are arable) (UNCCD 2006). Due to repeated natural disasters and economic hardship in the 1990s, a large proportion of traditional forestlands were degraded and/or destroyed. Additionally, substantial growth of firewood consumption to meet energy demands has only worsened the problem (UNDP 2003). Of the total 9 million ha of forestlands, about 1.5 million ha have been deforested (UNCCD 2006). The resulting outcomes include acceleration of biodiversity loss, soil erosion, and deterioration of hydrological dynamics.

b) Land Degradation

Land degradation – the diminishment of productivity and regeneration capacities of ecosystems **–** is prevalent in mountainous areas throughout DPR Korea. The critical issue in land degradation is soil erosion; a direct result of deforestation and unstable crop cultivation in sloping lands. The current soil erosion rate on sloping lands is approximately 40~60 tons/ha/year with a maximum value of over 100 tons/ha/year (UNCCD 2006). Furthermore, land degradation can occur in many forms, including degradation of rice paddy fields, water logging and loss of agricultural lands due to infrastructure construction, degradation through intensive mono-cropping, damage of coastal areas by tidal waves and so on.

c) Degradation of Marine and Coastal Ecosystems
As a result of DPR Korea's placement between two seas, the country is rich in marine and coastal ecosystems. However, abnormal climate change, over exploitation, human development, reclamation of tidelands for crop cultivation and salt farming, and illegal discharge of untreated wastewater and sewage into rivers threatens these systems (UNEP 2003).

d) Loss of Biological Diversity
Due to its geographical position DPR Korea is endowed with a high level of biological diversity compared to the size of its territory. However, in recent years the DPR Korea has experienced rapid and accelerated reduction in biological diversity as a result of population growth, deforestation and habitat destruction, over exploitation, the introduction of alien invasive species and pollution, among others. Although there are about 200 protected areas and forests of various kinds throughout the country, they are managed poorly, reducing the efficiency of biodiversity conservation efforts.

e) Degradation of Water Quality
The DPR Korea has an abundance of water resources. However, factors such as population growth, urbanization, industrial and infrastructure development, increased solid waste, sedimentation and deforestation have decreased water quality. Changes in the hydrological features of rivers and lakes, combined with water pollution, can bring about changes in the aquatic environment and its surrounding area. Increases in biomass of algae and zooplankton, red and blue tidal phenomenon, increased concentrations of coliform bacteria, and excess concentrations of heavy metals are only some of the changes brought about by the degradation of water resources (UNEP 2003).

f) Air Pollution
As a result of industrial processes, air pollutants such as sulfurous acid gas and aerosols are emitted. In most cases, these poisons exceed their standard limits. Deforestation and land use change are additional factors adding to the increase of carbon levels.

g) Solid Waste
The lack of proper technical capacity to create a sound management system for solid wastes has negatively impacted the hygienic and sanitary qualities of soil, water and air.

h) Natural Disasters
In DPR Korea, natural disasters are mainly caused by droughts, floods and tidal waves. Such natural disasters are furthered by activities such as deforestation and changes in climatic patters.

1.6 Current National Policy and Legislation

Established in 1961, the Ministry of Land and Environment Protection (MLEP) is the governing authority responsible for the supervision and coordinated management of the land and environmental assets of the country. It includes departments such as the Land Supervision Department, the Land Use Planning Department, the Forest Department, the Road Management Department and the River and Stream Management Department to monitor and control the overall land use patterns of the country. It has established nationwide institutional systems for land and environmental protection from central to provincial and local levels. More specifically, there are land resource controlling bodies, forest resource controlling bodies and forest management units established under the Department of Land and Environment Protection at city and county levels. There are also scientific and technical institutions under the MLEP, including the Land Development Planning Institute, the Central Forest Design Technical Institute and the Environmental Protection Institute.

The Ministry of Timber Industry manages 5 million hectares of forestland for industrial timber production and is also in-charge of forest management in its area. Both supervisory/coordinating authorities and user sectors implement the policies and legislation related to land management.

In consideration of the growing concern over land degradation, the government implemented policies and legislation designed to preserve land resources and promote sustainable use. Key aspects of the government's land management policies are as follows:

- To prepare a land development master plan and carry out development activities of land and natural resources prospectively based on it.

- To continually increase the area of cultivated land while avoiding the encroachment on existing farmland, and to complement the irrigation system for agricultural production at a higher level.

- To improve the management of mountains and rivers as an important means of securing safe agricultural production.

- To improve livelihood and promote economic development in rural mountainous areas through integrated management of mountain resources.

- To protect the land from pollution and increase the effectiveness of land use.

- To promote broad participation and partnership in the protection and management of land resources.

Additionally, the above government policies related to land management are reflected in various laws and regulations. The representative main laws are as follows:

- DPRK Law: specifies the provisions on land tenure, land development master planning, and land protection and development, as well as on the management and supervision of land resources.

- The DPRK Environmental Protection Law: outlines the basic principles of environmental protection, preservation and promotion and its control measures.

- The DPRK Land Development Planning Law: describes the provisions for the principles of land planning procedures and methodologies.

- The DPRK Forest Law: provides general regulations on forest resources management comprising definitions of forestland resources, reforestation/afforestation, protection and use of forestland resources.

- The DPRK Law on Agriculture: provisions on the diversified development of agriculture, completion of irrigation systems and their management, protection of agricultural lands against natural disasters and the prevention of land degradation.

- The DPRK Water Resources Law and Law on Rivers and Streams: deals with the development, conservation and use of water resources. It includes a provision that water resources should be preserved through nationwide and public involvement, and quality and quantity of water resources should be conserved for human and natural consumption.

The DPR Korea displayed its commitment to the global environment by joining the multilateral environmental agreement. The government signed the UN Convention on Biological Diversity (UNCBD) and the UN Framework Convention on Climate Change (UNFCCC) in June 1992 and became a member of these conventions in April 2004. Recently, it also acceded to the Kyoto Protocol and Cartagena Protocol on bio-safety.

Additionally, preparation of the National Action Plan (NAP) to address land degradation was started in June 2005. The initial national awareness workshop on activities relating to combating desertification/ land degradation and the National Action Plan preparation was held on June 15 -16, 2005 in Pyongyang with support from the UNCCD Secretariat, involving representatives from various government agencies, scientific and public organizations.

1.7 Terms and Definitions

Degradation of forest land mainly occurs in the form of reduction of forest land area; reduction of volume and density of forest stands; reduction of vegetative cover; decline of soil organic matter, erosion and landslides, drying and reduction of water catchment capacities; soil compaction and destruction of food chains.

Degradation of agricultural lands occurs in the form of reduction of arable land area; erosion; loss of soil nutrients, acidification and salinification; drying and reduction of water catchment capacities; water logging; soil compaction; and soil pollution. Such phenomena result in: the decline of soil productivity; reduction of natural regeneration capacity of the soil; loss of biomass; decrease of water regulation functions; reduction of soil carbon sinks; and the decline of social land values (UNCCD 2006).

2. Status of Forest Rehabilitation

2.1 History of Degradation – Causes and Effects

Land degradation in the DPR Korea is chiefly linked with forest destruction. In this section, land degradation will be considered in the following categories:

i) degradation of forestland *and*
ii) degradation of agricultural land.

Since the 1990s when the country experienced repeated natural disasters and economic difficulties, the rate of land degradation has been steadily increasing. Activities to combat these natural and economic pressures included the conversion of forestland for crop cultivation, forest logging, and the extraction of forest products. As a result, non-forested lands increased from 361,000 ha in 1993 to 1.5 million ha in the late 1990s. Approximately 360,000 ha of forestlands were lost during this brief period alone (UNCCD 2006).

The degradation of land can also be caused and accelerated by natural disasters associated with the destruction of forest ecosystems and the worldwide climate change phenomenon. One such example is the extreme flooding in Pyongyang City and Taedong River basin areas in August 1967 when 400 mm of rain fell per hour in the upstream river sections. During the last decade, the frequency and intensity of natural disasters such as floods, droughts and tidal waves have increase, causing severe damage to agricultural and forest resources. Through successive floods in 1995 and 1996, 1.3 million ha of agricultural lands were damaged and lost by inundation and sedimentation. It brought about costs of US$ 1.038 billion in the agricultural sector in 1995 and US$ 2.271 billion in all economic sectors in 1996. In addition, a drought in 1995 devastated approximately 466,000 ha of arable land (UNCCD 2006). As stated above, land degradation is a nationwide phenomenon. It directly results in the reduction of agricultural productivity and regeneration capacities of biological resources, and has severe and adverse impacts on livelihood improvement and sustainable development in rural areas.

2.2 Trends in Rehabilitation of Degraded Forests

In 1994, the National Coordinating Committee on Environment (NCCE) was founded to coordinate national activities related to global environmental issues. NCCE is composed of representatives from concerned ministries and scientific institutions such as the Ministry of Land and Environment Protection (MLEP), Ministry of Agriculture, and Ministry of Forest Industry. The NCCE is a coordinating body, and at the same time, a national focal point in implementing the national obligations to UNCCD.

As a result of the significant adverse impacts on agricultural production and social development, deforestation and the degradation of agricultural lands has become one of the country's main barriers to the sustainable development of its economy and society. Entering the new millennium, the government has taken decisive measures to reverse land degradation and deforestation.

CASE STUDY "Turn-out Month for Land Management"

Following the instruction of Great Leader Comrade Kim Jong Il, the resolution to promote land management activities through a 'turn-out' of all nations was adopted in September 1996.

As an implementation measure of this resolution, the government launched a nationwide land management campaign by setting up “General Turn-out Month for Land Management” in each spring and autumn to promote the reforestation and rehabilitation of degraded forests, realignment of land resources, river banks management and other land management works through participation at all levels and sectors. As a result, the annual reforested area reached 130 thousand ha, tens of thousands of paddy and non-paddy fields were realigned at regular scales, and long lines of river banks were repaired. In particular, considering the limited land area available for crop cultivation and trends of modern agricultural development, the government’s initiation and implementation of land readjustment projects resulted in additional new rice cultivation areas through the standardization of irregular rice fields.

However, such a large scale project had many problems. Coordinating people and resources proved to be difficult, and a lack of skilled and knowledgeable planters resulted in wasted and inefficient resources (ie. trees were planted in faulty conditions or in a poor manner).

3. Research, Education Capacity, and Extensions

3.1 Research Activities and Projects

- **National Action Plan (NAP) 2005-2009**

In June 2005 preparations began to develop a National Action Plan (NAP) to address land degradation in DPR Korea. The National Action Program consisted of a strategy, programs and activities. An awareness workshop was held in 2005 to increase awareness among stakeholder agencies on the concepts, issues and international activities of combating land degradation and the national obligations to UNCCD. It was also an opportunity to share and exchange views about the options and ways to achieve sustainable land management.

Through a number of activities including information gathering and analysis, frequent consultations and group discussions, and two internal workshops, the NAP preparation working group reviewed the status of land degradation, identified its main issues, causes and constraints and, based on them, prepared a draft for NAP. The preparation of NAP to combat land degradation proceeded in close collaboration with the National Capacity Needs Self-Assessment (NCSA) project, especially with the ‘land degradation’ working group. Government representatives participated in the 7th Conference of the Parties (COP) to UNCCD held in Nairobi (September 15-28). The final NAP validation workshop was convened in June 15-17, 2006 in Pyongyang.

Among the NAP’s priorities for international cooperation are

1) the establishment of a GIS-based, integrated national database on land use and management;

2) improved technical knowledge transfer and dissemination;

3) technical transfer of sloping land management and agro-forestry technologies;

4) strengthening of the capacity of cooperative farm management;

5) technical transfer and demonstration of watershed management approaches;

6) development of a national forest program;

7) capacity building in early warning systems related to disaster reduction and preparation response planning;

8) public awareness raising for combating land degradation and human resources development.

- **National Capacity Building Action Plan for the Implementation of Global Environmental Conventions**

The DPR Korea Action Plan on capacity building for the implementation of multilateral global environmental conventions was developed at the end of the NCSA project (2004-2005). It has set the following cross-cutting priority areas for capacity building:

1) improvement of the national institutional framework for the implementation of Rio conventions;

2) strengthening of international exchange and cooperation for technical knowledge transfer in the environmental field;

3) strengthening of the capacity of integrated watershed management and demonstration;

4) improvement of infrastructure, knowledge and information collection, dissemination and sharing in the environmental field;

5) training of experts and capacity building for reeducation in the field of environment; *and*

6) raising public awareness on Rio Conventions.

- **National Plan to Combat Land Degradation**

In May 2003 the DPR Korea Cabinet adopted a resolution to strengthen the management of mountain and river systems. The main contents of this resolution is:

- to prevent deforestation and forest degradation and implement reforestation and greening programs throughout the whole country;
- to improve river and stream management;
- to promote participation in land management activities;
- to strengthen scientific research and studies on mountains and river management as well as on forest sciences; *and*
- to improve the state leadership and reinforce the supervision and control of the land management practices.

3.2 Constraints and Gaps in Current Land Management

Weakness in Databases and Information Sharing Related to Land Management

One of the critical issues faced by land managers in DPR Korea is the incompleteness of comprehensive databases related to land use and degradation. It will be necessary to identify criteria and indicators to assess land degradation and to establish an integrated information database related to land resources management and degradation through technical capacity strengthening, and the exchange of information among relevant stakeholder agencies.

Environmental Policies Revision for Sustainable Land Management

It is important to revise policies and legislation to adjust to the country’s changing environmental status in a timely manner. It requires the revision and update of existing legislations and practical guidelines by replacing their provisions on old management approaches and technologies with advanced ones and, if necessary, by producing new laws, regulations and guidelines to provide for effective prevention of land degradation and promotion of sustainable land management.

Lack of Proper Awareness and Knowledge
In combating land degradation, there is a need for a clear perception and understanding of the values and importance of land resources. Although the existing educational institutions related to land management deal with the scientific and technical as well as managerial issues, there are often gaps in their training contents. Additionally, the lack of advanced knowledge and techniques on land degradation and sustainable approaches to land management among staff and employees active in land management and resource use sectors has become another constraint to the sustainable and effective management and use of land resources.

- **Insufficient financial resources and low technical capacities**
DPR Korea's economic stagnancy coupled with frequent natural disasters over the last decade has had significant adverse impacts on the economic development and livelihood of the country. Limited access to advanced technologies and investments are also another challenges.

- **Natural geographic conditions and impacts of climate changes**
The geographic and climatic conditions of the country are key factors driving land degradation. Rapid climate change and global warming contribute to the increase of mean temperature. The main factors accelerating the land degradation process are frequent natural disasters including droughts and floods.

3.3 Educational Capacity

Educational institutions related to land management include the Faculty of Global Environmental Sciences, and Faculty of Life Sciences at the Kim Il Sung University as well as agricultural colleges in each provinces. Pyhyon Land Management College also serves as an educational base to train managerial and scientific experts in the field of land management.

3.4 Extensions

In addition to the organizations mentioned throughout this paper, DPR Korea includes the following relevant social organizations: Kim Il Sung Socialist Youth League, the Union of Agricultural Working People of Korea, the General Federation of Trade Unions of Korea, and the Korea Nature Conservation Union.

The DPR Korea worked extensively with the United Nations Environmental Program (UNEP), United Nations Development Program (UNDP), United Nations Industrial Development Organization (UNIDO), United Nations Educational, Scientific, and Cultural Organization (UNESCO), Food and Agricultural Organization of the United Nations (FAO), International Maritime Organization (IMO), United Nations Convention to Combat Desertification (UNCCD), and the Korean-Swiss Agricultural Programme on the National Action Plan.

4. Conclusions and Recommendations: Future Policies

It is commonly accepted that DPR Korea has followed its own development path largely isolated from the rest of the world. For this reason, it lacks capacity, knowledge, technical expertise, and training to adequately address its environmental concerns. Possible solutions to these problems include the necessity to identify criteria and indicators for accurate assessment of land degradation and to establish integrated information databases related to land resource management and degradation through technical capacity strengthening. Overall, weak databases, baseline knowledge, lack of proper awareness, insufficient financial resources, and low technical capacities contribute to the country's land degradation problem. Over the past several years, various assessments and evaluations have been conducted addressing the ecological, socio-economic and technical aspects of land degradation in DPR Korea. The following major recommendations were made in the 2006 National Action Plan to Combat Desertification/Degradation (2006-2010) (UNCCD 2006) to improve the current situation:

4.1 Establishment of a National Land Management Information Database and Development of a National Strategy and Action Plan for Sustainable Land Management

The establishment of a land use information database is a challenging requirement for the integrated management of the country's land resources. However, it is an important tool to increase awareness among scientists and the general public regarding integrated and rational management. A database would also act as a starting point for monitoring and evaluating the implementation process of management plans, as well as to highlight changes in land use and degradation patterns. A comprehensive national land information database – GIS based **–** would support the development of a strategy and action plan for sustainable land management. It would enable the timely recording of land use changes and promote the sharing and exchange of information among relevant stakeholder agencies.

4.2 Transfer and Dissemination of Technologies for the Rehabilitation of Degraded Forestlands and the Establishment of Sustainable Firewood Forests

Deforestation is the main factor responsible for land degradation and usually occurs as a result of excessive firewood consumption. Despite efforts and advocacy to combat the problem, soil losses and erosion in sloping lands are frequent, as a result of the serious energy shortage in rural areas. To solve this problem, innovative approaches and measures for proper land management will be needed.

4.3 Knowledge Transfer on Sloping Land Management and Agro-forestry as Part of the Intergraded Management of Mountainous Areas

Slope management and agro-forestry are considered to be promising options to promote safe food production and efficient rural energy supply. Simple knowledge transfer is insufficient; there must be demonstrations in different land categories in order to promote proper use of these technologies.

4.4 Capacity Building of the Cooperative Farm Management Committee and Demonstration of Sustainable Management of Agricultural Lands

The sustainable development of agricultural lands is a prime and crucial issue to ensure national food security. In DPR Korea, the agricultural land consists mainly of paddy, non-paddy fields and fruit orchards with a per capita average of about 0.08ha (UNCCD 2006). A large proportion of non-paddy fields are located on sloping lands covering about 360,000 ha. As a result of unsustainable cultivation practices employed on these lands, the soil's top layer became more and more eroded and the nutrient content decreased significantly. Intensive use and lack of organic farming on rice cultivation lands has also lowered nutrient content in the soil. In this context, the implementation of sustainable land management requires capacity building of Cooperative Farm Management Committees, as they are the basic units of agricultural land management and agricultural production.

4.5 Transfer and Demonstration of Watershed Management (Capacity Building and Demonstration of Participatory Watershed Management and Sustainable Rural Development)

The territory of DPR Korea covers more than 10,000 watersheds and 73.2% of the land is occupied by forestland. Annual rainfall is about 1,000~1,200 mm (UNCCD 2006). It can be assumed that watershed management is the key activity for environmental protection and sustainable rural development. As in many developing countries, watershed degradation is one of the main environmental problems in DPR Korea, owing to socio-economic development activities and climate change. The main issues in watershed degradation are related to deforestation and land use change, improper land management, infrastructure development, and pollution. Solving the watershed degradation issue is a prerequisite for environmental protection and livelihood improvement in DPR Korea.

4.6 Development of a National Forest Program; Capacity Building of the District Forest Management Board (DFMB) and Industrial Forest Management Board (IFMB) at County Level

Forest Management is an essential part of addressing land degradation and plays a vital role in biodiversity conservation and mitigation/adaptation of climate change. Covering 73.2% of total land area, forestland contributes significantly to the socio-economic development and protection of agriculture and the environment.

4.7 Creation of an Effective Early Warning System and Planning for Natural Disaster Management

The occurrence of disasters is a natural phenomenon. However, it is becoming more common and costly. The successive floods in 1995 and 1996 and the droughts and tidal waves the following year caused tremendous damages to the agricultural and forest sectors as well as to settlement areas. The establishment of early warning systems and the consideration of natural factors in land use planning are essential for maintaining and rehabilitating viable ecosystems.

4.8 Promotion of Public Awareness and Development of Human Resources for Combating Land Degradation

To reverse the negative trends of land degradation, including desertification, droughts and deforestation at both national and global scales, it is necessary, first and foremost, to raise public awareness and concern for the issues. Land degradation is named as one of the major environmental concerns in DPR Korea. Yet there remains a poor understanding among the public on the ecological functions and services of forests, land degradation issues including soil erosion and salinization, and their causes and consequences. Therefore, raising public awareness and developing informational resources are the prerequisites for reversing the consequences of land degradation and moving towards sustainable land management at national and local levels.

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Forest Restoration in Korea

Joon Hwan Shin[1], Pil Sun Park[2] and Don Koo Lee[2]

1. General Information

1.1 Geographic Information and Topography

The Korean Peninsula is located in the east end of the Eurasian Continent and in the west end of the Pacific Ocean geographically, and lies in the East-Asian Monsoon belt climatically. The Korean Peninsula encompasses 221,000 km^2, of which 45% (99,600 km^2) makes up the Republic of Korea. The topography is complex with two major mountain ranges. The Baekdu Daegan Mountain Range is extending south from the Baekdu Mountain to the Jiri Mountain, forming the geological backbone of the country. It parallels the east coast, approximately 10 to 100 km inland from the East Sea, dividing the watersheds of the western and eastern slopes. Smaller mountain ranges run parallel to each other in a northeast-to-southwest direction (Kong, 2002). Consequently, while the western and southern coasts have thousands of islands, small peninsulas and bays, steep mountains along the east coast steep down almost to the shoreline creating a simple coastline with only small streams, and a few narrow strips of alluvial beaches.

The location and topography of the Korean Peninsula brings Korea four distinct seasons. Spring and autumn are relatively short while summer and winter are rather long. Summer is hot, humid, and wet. From June to September, summer monsoons hit the Peninsula, bringing more than 60% of the annual precipitation. Heavy showers with thunder and lightning are common, with periodic flooding. Winter is dry and freezing cold due to north-westerly Siberian air masses that sweep down from the north. The average temperature of Korea is hotter in summer and colder in winter than that of the countries located at similar latitudes on the continent. Mean temperatures are 12-14 degrees centigrade in the central and southern region, and 3-10 degrees centigrade in the north. Annual mean precipitation ranges from 600 mm to 1600 mm. The rainy season beginning in late June lasts approximately 30 days with more than two typhoons between June and October striking the Peninsula every year, resulting in heavy rainfall in this season (Shin, 2002).

According to the variation of seasonal patterns of temperature and rainfall, there are three major forest zones on the Korean Peninsula: warm-temperate forest, cool temperate forest, and sub-frigid forest (or sub-alpine forest). The warm-temperate forest covers the area south of 35°N, a part of the southern coastal regions, including Jeju Island and many smaller islands where the annual mean temperature is above 14 degrees centigrade. Naturally, this zone is dominated by evergreen broad-leaved trees including *Quercus acuta, Camelia japonica*, *Castanopsis cuspidata, Cinnamomum japonicum* and various bamboo species. However, most of the natural forests were destroyed by forest fire and overexploitation, and changed to deciduous hardwoods, mixed or pine forests. The cool temperate forest zone covers most of the Korean forest between 35° and 43° N except the mountainous highlands and southern coastal zone. The annual mean temperature ranges from 6 to 13 degrees centigrade. Species predominantly grown in this region are deciduous broadleaved trees, with pine forests established after having been destroyed by natural or human causes. Major tree species in this zone are *Quercus* spp., *Acer* spp., *Zelkova* spp., *Carpinus* spp., *Prunus* spp., *Fraxinus* spp., *Betula* spp., *Pinus densiflora* and *P. koraiensis*. This zone can be divided into three sub-zones, namely southern, central and northern temperate forest sub-zones. The sub-frigid temperate forest covers the northern end of Korea and high mountainous area where the average annual temperature is 5 degrees centigrade and lower. Dominant tree species are *Abies nephrolepis*, *Picea jezoenis*, *Larix gmelini, Juglans mandshurica*, and *Betula platyphylla*.

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1.2 Population

The population of South Korea (the Republic of Korea) was reported to be 48.3 million as of 1st July, 2005 (Korea Forest Service, 2006). The annual rate of increase is 0.44, which is one half of that in 2000. In 2005, the birth rate of women of child-bearing age was 1.08 per woman, which was the lowest level in the world. However, South Korea is one of the most crowded countries in the world with very high population density, 485 persons/km^2. The high population density is a constraint for forest conservation.

1.3 Economic Situation

(Source: http://ecos.bok.or.kr/)

- GDP (gross domestic product) at current prices: 887 billion US$ (2006year)
- Per capita GNI (gross national income): 18,372 US$ (2006year)
- Growth rate of GDP at constant prices: 5.0 (2006year)
- Totally employed: 22.7 million persons (Jan 2007)
- Unemployment rate: 3.6% (Jan. 2007)
- International reserve: 2,402,229 million US$ (Jan 2007)
- Foreign trade (2006):
    - Exports (customs clearance): 325,465 million US$
    - Imports (customs clearance): 309,383 million US$

1.4 Natural Resources (Source: Korea Forest Service, 2006)

The total area of South Korea is 8.965 million ha and the forest area occupies 6.394 million ha, about 64% of the national land area at the end of 2005. The forest area has decreased little by little during the past 10 years. The annual decrease amounts to 5,400 ha.

Korean forests are composed of coniferous forests with 2.699 million ha (42.3%), broadleaved forests with 1.659 thousand ha (25.9%), mixed forests with 1.875 million ha (29.3%) and other forests with 161 thousand ha (2.5%). While coniferous forests have decreased a little during the last 10 years, we noticed an increased trend for broadleaved forests and mixed forests.

In the coniferous forests, the main species is natural pine (*Pinus densiflora*) with 1.483 million ha (54.9%), followed by Larix forests with 464 thousand ha (17.2%), *Pinus rigida* forests with 411 thousand ha (15.2%), and *Pinus koraiensis* forests with 231 thousand ha (8.6%). Pine wilt disease, pine needle gall midge and black pine blast scale have led to a decrease of natural pine forests.

In 2005, the growing stock of South Korean forests amounted to 506 million m^3 and the growing stock per ha was 79.2 m^3, which means an increase by 3 m^3 compared to 2004. The growing stock by forest types is 217 million m^3 in coniferous forest, 153 million m^3 in mixed forest, and 136 million m^3 in broadleaved forest. The annual growth of growing stock in South Korea has increased rapidly throughout the recent ten years.

1.5 Environmental Issues

Pinus densiflora and *Quercus* species are the dominant tree species and form mixed forests at lower elevations. *P. densiflora* grows naturally on relatively dry and poor sites and can be successfully regenerated after disturbances. Pine forests were protected for a long time particularly during the Chosun Dynasty (1392-1910) and had affected the cultural life of many people.

Large forested areas were devastated by overexploitation until the 1950’s for fuelwood supply. In 1960, there were about 2.4 million households in the country in need of about 0.5 ha of forests per household. In order to meet the fuel demands of these households, about 1.2 million ha of total fuelwood plantations were required (Lee and Suh, 2005). Most of the forest areas were degraded with only 10.6 cubic metres of growing stock left resulting in serious soil erosion problems. With successful implementation of the First and Second 10-year Forest Development Plans, from 1973 to 1987, fuelwood plantations have been successfully established and most of the degraded forests have been also rehabilitated by all the efforts and cooperation among government organizations, NGOs and foresters. In this period, Korean forests were dominated by *P. densiflora,* a pioneer species best suited to colonize denuded sites.

Owing to rapid economic development and urbanization efforts of Korea, there has been an unprecedented demand for new land. Clearance of forests for the construction of various types of social infrastructure, industrial estates and new towns has been the determining factor for the destruction and fragmentation of the forests. The Korean economy has grown during this period and there was a shift from wood to fossil fuels as the major energy source. Therefore, the growing stock and forest site conditions have recovered while forest areas have decreased a little. As a result of both anthropogenic activities (eg. land-use change and planting) and natural processes including succession and biological effects (insects and pathogens), the share of *P. densiflora* forests has decreased being replaced by *Q. serrata, Q. mongolica* or other plantations.

As shown in Figure 1, the forest area disturbed by forest fire and landslides has increased recently in Korea. It is surprising that these extreme climate-related events were driven by early stages of ongoing global warming caused by increased artificial emissions of greenhouse gases. The recent tendency of frequent climate-related disturbances is a worldwide phenomenon (IPCC, 2001). We plotted annual landslide areas in Korea against annual precipitation, and could find a linear limitation line below which each point is located (Figure 2). However, the plotted point of landslide area in 2002 was located beyond the line due to the uncommon destruction by heavy rainfall accompanied by Typhoon Rusa. The typhoon destroyed the same area previously burned by a big forest fire in 2000, and showed an amplified effect (Lim *et al*., 2006). The other area beyond the limit damaged in 2006 was caused by two huge rainfall events, namely Typhoon “Ewiniar” in Gyeongsangnam-do Province and the localized torrential storm in Gangwon-do Province.

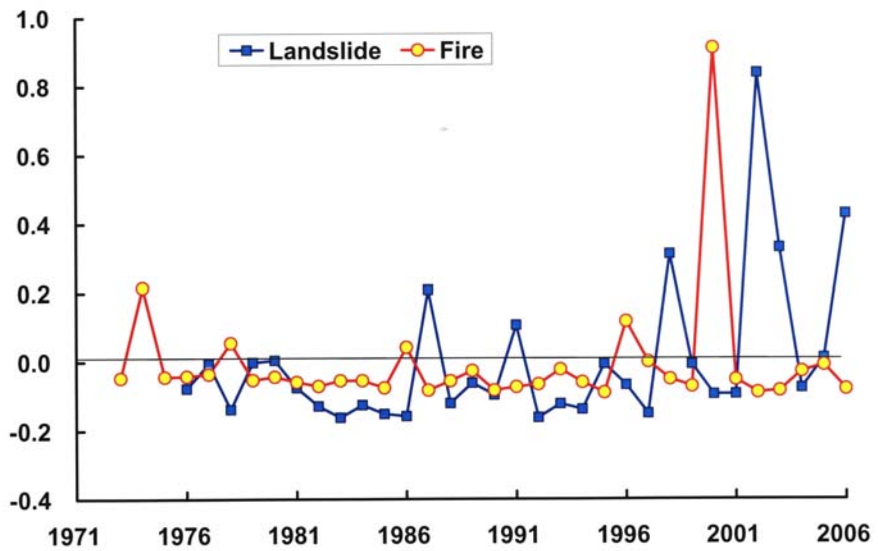


Figure 1: ***Changes of Forest Area Disturbed by Landslides and Forest Fire in Korea***
Y axis is standardized anomaly as $(X_i - X_{mean})/(X_{max} - X_{min})$. Forest fire areas are taken from KFS (2006) and landslide areas from internal data of the Korea Forest Service.

1.6 Current National Policy and Legislation
(Source: http://english.foa.go.kr/)

The on-going implementation of the Fourth National Forest Plan intends to conclude the government-led reforestation programs and shift to building forest management policies addressing diverse social needs and international trends. The primary objective of the Fourth Plan is to establish and develop a foundation for sustainable forest management. Under this objective, the Korea Forest Service puts special

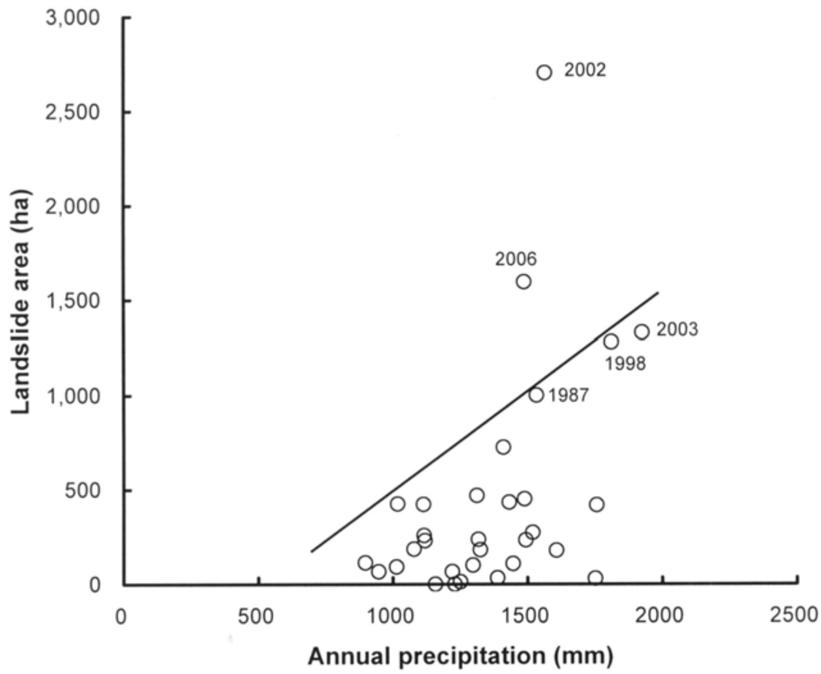


Figure 2: ***Relationship between Annual Precipitation and Landslide Area in Korea***
In 2002, Typhoon Rusa caused heavy rainfall and destroyed the previously damaged area by a big forest fire in 2000 showing amplified effects.

emphasis on developing valuable forest resources, fostering competitive forest industry, and enhancing forest health and vitality for the people.

Major action plans are:

1) to strengthen forest expert training and establish new multi-management systems;
2) to extend commercial forests and the marketing system through promoting the timber industry;
3) to reinforce forest ecosystem conservation;
4) to establish an effective forest fire control system;
5) to enhance urban forest management for creating pleasant living conditions and a sound recreation culture;
6) to conduct mountain village development programs;
7) to provide a forest management mechanism in preparation of the unification of Korea;
8) to strengthen international cooperation in forestry; *and finally*
9) to increase overseas plantations.

In recent years, the sustainable forest management (SFM) paradigm which stresses the multi-functions of forests has been given much emphasis internationally. So as to develop a domestic SFM framework, criteria and indicators have been established at the national level and efforts have been made to provide the basis for local implementation.

There are ten laws relating to forests and forestry. The Forest Law was enacted in 1961 to promote forest protection and forest development as well as to enhance forest productivity and public functions. The Law prescribes the extension and utilization of forest resources, sustainable development of forests, conservation of natural forests and protected forests as well as the management of national forests.

Aside from the principal Forest Law the Korea Forest Service enacted the Erosion Control Act in 1962 for the prevention of denuded forest lands and effective erosion control; the Act on Forestry Cooperatives Federation in 1993 for the organization and functions of Forestry Cooperatives; and the Act on Promotion of Forestry and Mountain Villages in 1997 for intensive management of private forests which are occupying 70% of the forest land in Korea.

In 2001, the Framework Act on Forests was established in order to meet diverse demands on forestry. The Act outlines basic principles and directions of forest policy and provides forest objectives and roles of foresters. Based on this Act, existing forestry provisions will be revised and all kinds of legislation and amendments will be set up to enhance the coherence of forest policies. This Act came into effect on May 24, 2001.

The Act on Promotion of Forestry and Mountain Villages was amended in 2001 to provide an institutional framework for reinforcement of the under-developed mountain villages and promotion of the forest industry. Also in 2001, the Act on Establishment and Promotion of Forest Arboretum was legislated and announced. The purpose of this Act is to secure the creation and operation of a forest arboretum in an attempt to create and enhance forest genetic resources which are expected to contribute to the development of the national economy.

Also, the Forest Land Management Act was enacted in 2002 so as to prevent frequently occurring careless land development causing reckless damage to forests. It also aims to improve the approval process for forest land use change. In 2003, the Act on Protection of the Baekdu Daegan Mountain System was established with a view to conserve and protect the core of forest ecosystems in Korea. Furthermore, a study was undertaken on the Forest Law to establish specialized legislations and to reflect the administrative demands on forest resources and national forest management. The study focused on the current structure of the Law and ways to improve it. As a result, the development of the respective legislative bills on forest resource development and management, national forest management, and forest culture and recreation are currently being finalized. Based on these changes remarkable improvements are expected in forest management with balanced development and conservation. Advanced disaster control systems and sound forest development systems will be provided as well.

1.7 Terms and Definitions

Forest rehabilitation means a management applied in degraded forest lands, which aims to re-establish site productivity and protective functions and many of the ecological services provided by a functional forest or woodland ecosystem (IUFRO 2005). Forest restoration means a management applied in degraded forest areas which aims to assist the natural processes of forest recovery in a way that the species composition, stand structure, biodiversity, functions and processes of the restored forest will match, as closely, as feasible, those of the original forest (IUFRO 2005). Forest landscape restoration can be defined as a process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscape (Lamb and Gilmour, 2003). Forest health means the perceived condition of a forest derived from concerns about such factors as its age, structure, composition, function, vigor, presence of unusual levels of insects or disease, and resilience to disturbance (Helms 1998, recited from IUFRO 2005). Perception and interpretation of forest health are influenced by individual and cultural viewpoints, land management objectives, spatial and temporal scales, the relative health of the stands that comprise the forest, and the appearance of the forest at a point in time (IUFRO 2005).

2. Status of Forest Restoration

2.1 Pest Control and Restoration

Korean forests are vulnerable to pests and diseases since about 59% of forest stands consist of trees aged less than 30 years. Dominant forest pests and diseases, therefore, tend to greatly affect their growth. Among the 1,760 species of forest pests and diseases identified in Korea, most damages are caused by pine needle gall midge, mealy bug, Japanese alder leaf beetle, and white pine blister rust. The recent spread of pine leaf gall midge has greatly damaged the pine trees, one of the major timber resources of Korea. The fact that insecticides are used as pest control measures has caused ecological concerns on the possible hazards and negative effects on the forest ecosystem. Consequently, today most aerial pest control is conducted only for the extensive chestnut plantation which is the major source of income. Following the belief that prevention is the best protective measure against pest and diseases, the Korea Forest Service has been conducting Forest Pest Preventive Inspection since 1968 (http://english.foa.go.kr/).

Recently, the Korean pine forests have been seriously threatened by the outbreak of the pine wilt disease. The disease was first introduced in Geumjeong-san of Busan in 1988. Outbreaks occurred in limited areas of Gyeongsangnamdo, Busan, and Ulsan. However, in 2004, it was detected in Jeju and Pohang, and quickly spread to 10 cities and counties. Recognizing the severity of the attacks, a Special Prevention Plan for Pine Wilt Disease was established and intensive actions were undertaken. Currently, the government is endeavoring towards complete extermination by focusing on preventing further enlargement (http://english.foa.go.kr/).

2.1.1 Pine Moth (PM)

The pine moth (hereafter referred as PM) is a native pest in Korea and its outbreaks were recorded in 'The annals of the Chosun dynasty' from 1392 to 1863. Recently its occurrence decreased after mid 1970s (Figure 3) and now it is considered as an occasional pest in the inland of Korea. Periodicity of its occurrence was analyzed on the basis of recent changes in the density of PM and past records in 'The Annals of the Chosun dynasty'. The analysis showed that major and minor periodicities of PM were about 160 and 4~5 years, respectively (KFRI, 2004a). We guessed that the reduction of PM cannot be explained by the periodicity because minor fluctuation in the density of PM was not observed. Probably, changes in pine forest landscapes could be one reason for the decline of PM. One hypothesis can explain this reason. In high population density, PM suffered from high mortality induced entomo-pathogenic microorganism that acted like a density regulating factor. As Korean people did not rake up litters on the forest floor and the pine forest stabilized, microclimate in the pine forest would be humid, thus favoring micro-organisms.

Interestingly, changes in the phenology and the biology of PM were reported (Park, 2001). Usually, PM develops one generation per year whereas in their research two generations per year were observed by field survey on the basis of changes in the density of egg, larvae and pupae and by light traps on the basis of adult density. Park (2001) suggested that the increase in temperature induced this change because PM can complete two generations under temperatures observed in the field.

2.1.2 Pine Needle Gall Midge (PNGM)

The pine needle gall midge (hereafter referred as PNGM) is one of the major pests in pine forest being also an invasive species. Its occurrence was reported in Seoul and Mokpo in 1929 and then has spread. The damaged area from the 1960s onwards shows some fluctuation and a decreasing trend (Figure 3).

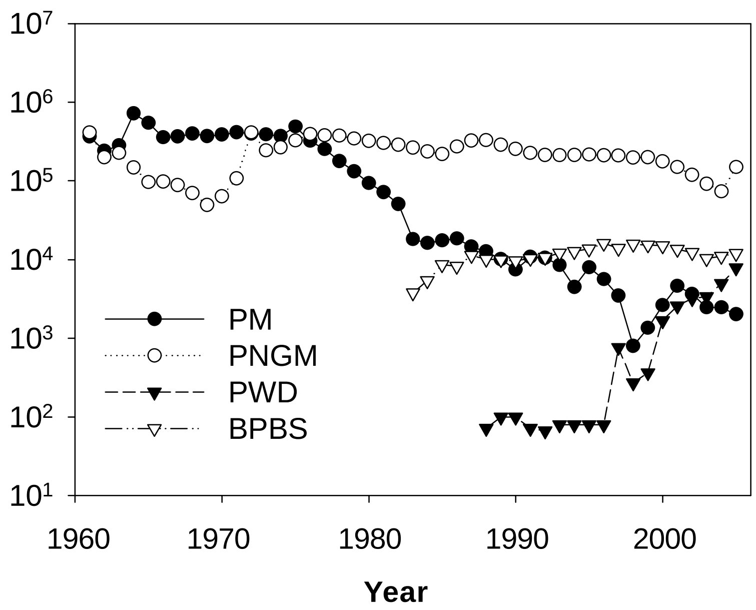


Figure 3: ***Sequential Changes in the Damaged Area of PM, PNGM, PWD and BPBS in Korea***

In 1964, PNGM invaded Danyang in Chungbuk. Then it spread to adjacent areas. The dispersal process of PNGM is shown in Figure 4. In 1996, PNGM has spread to all of the pine forests in Korea. Recently, the pattern of gall formation in each survey area was analyzed. Interestingly, 3 or 4 clusters were identified by cluster analysis using gall formation data from 1986 to 2005, as shown in Figure 5. Moreover, the pattern of clusters was similar to the dispersal pattern of PNGM. These results suggest that the infestation history is related with population dynamics of PNGM in each area. During the analysis of recent five year's data, from 2001 to 2005, only one cluster was identified. This suggests that the population dynamics of PNGM was synchronized in Korea and that PNGM is under the process of endemism. To clarify this hypothesis, further survey on population dynamics of PNGM will be necessary

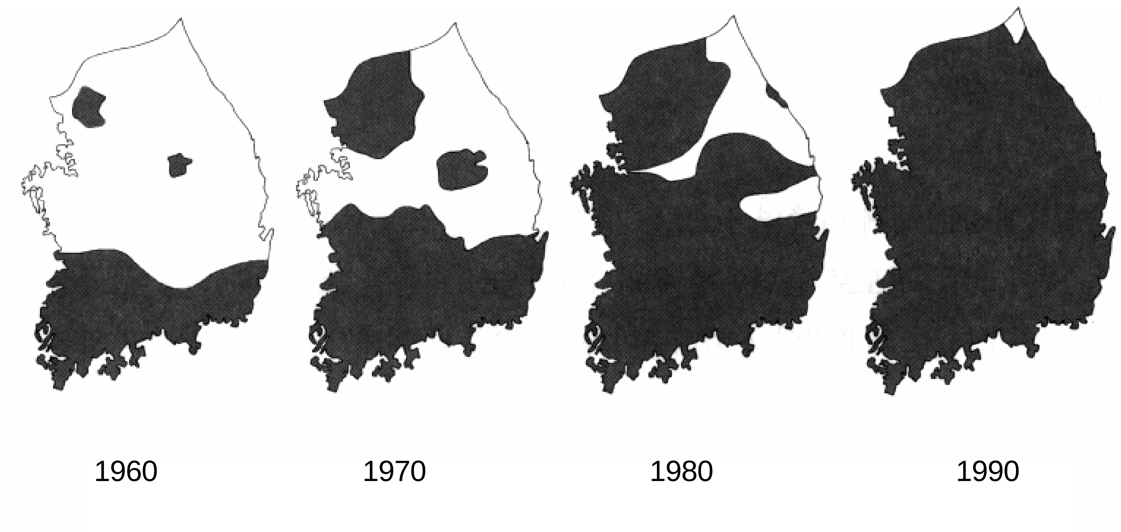


Figure 4: ***The Spread of Pine Needle Gall Midge Infestations in Korea from 1968 through 1992 at Eight-Year Intervals (Lee et al., 1997)***

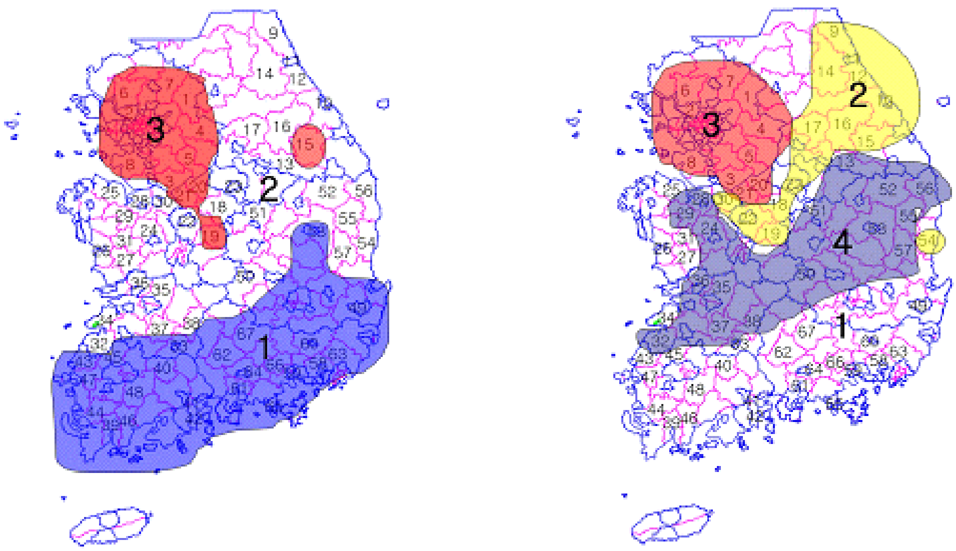


Figure 5: ***Clusters of Gall Formation on the Basis of 20 Years' Observation Data***
Left and right figures show patterns of 3 and 4 clusters, respectively.

As biological control agents parasitoids parasitizing PNGM have been studied by many researchers (Jeon *et al*. 2006; Park *et al*. 2001 and references therein). At the initial stage of interaction between PNGM and its parasitoids, the relationship between parasitoids and PNGM was weak but a positive relationship between PNGM and parasitoids density was observed after an early stage of interaction

(Jeon *et al*., 2006). However, this does not mean that the parasitoids would completely suppress PNGM because the population dynamics of PNGM had a periodicity and the parasitoids could not suppress PNGM at the stage of outbreak. Therefore, to protect pine forest from damages by PNGM, supplemental methods such as chemical control are needed when an outbreak of PNGM occurs.

2.1.3 Black Pine Blast Scale (BPBS)

The black pine blast scale (hereafter referred as BPBS) is also an invasive species and its first occurrence in Korea was reported in Goheung, Jeonnam. Then, it was dispersed to the southern area of Korea. It is known that its host is restricted to black pine. Currently, its dispersal slowed down, and thus its distribution is restricted to southern Korea. The reason for the restriction of its distribution has not been clarified yet. However, its host distribution and microclimate are possible causes for slowing down its dispersal.

2.1.4. Pine Wilt Disease (PWD)

The pine wilt disease (hereafter referred as PWD) is also an invasive species and is known as a lethal disease to Pinus species. Until 2005, the Japanese red pine and black pine which are hard pines were infected by the pine wilt disease but in 2006 the Korean white pine which is a soft pine was found infected by the pine wilt disease as well. Interestingly, it is suspected that the vectors and symptoms of PWD and PWD in Korean white pine are different from those in red pine. This new disease in Korean pine forests will put a selection pressure on Korea pine forests, and thus it will induce changes in the Korean forest landscape.

For the protection of the pine forest landscape many control methods have been applied. Basically, pine trees infected by the Pine wilt nematode were cut and then fumigated, burned or crushed. In addition, chemical control methods have been used to reduce the density of vectors of PWD or to protect valuable pine trees. Moreover, biological control methods using parasitic wasp and microorganism are being tested.

2.1.5 Oak Wilt Disease (OWD)

The first occurrence of the Oak Wilt Disease (hereafter referred as OWD) in Korea was reported in 2004 followed by the process of dispersal. OWD is caused by a fungus called *Raffaelea* sp and transmitted by the bark beetle *Platypus koryoensis.* This disease is considered a hazard agent to oak forest landscapes in Korea. Unfortunately, the reason for the outbreak of the bark beetle calamity is not clear. The infected oak trees were cut and fumigated to reduce the bark beetle density. In addition, new control methods are being developed.

2.2 Erosion Control

2.2.1 History

The forest areas in Korea are susceptible to erosion because of steep mountain slopes and concentrated rainfall in summer. The loss of topsoil caused by erosion affects soil fertility, ultimately degrading forest land. First efforts on erosion control date back to 1907. Records show that the government (Taehan Empire) initiated an erosion control project around the outer boundaries of Seoul (http://english.foa.go.kr/).

Since the 1960s, South Korea put much effort in the rehabilitation of denuded land through erosion control under strong government programs which have produced some remarkable results. In the 1950s, deteriorated areas reached more than 680,000 ha (about 10 % of the whole forest land of South Korea) because of the Korean War and reckless and illegal felling of trees throughout several decades. The deteriorated area decreased to 120,000 ha in 1972 (http://english.foa.go.kr/). After successful implementation of the First and Second National Forest Plans, most denuded hillsides and coastal areas were completely restored. The Third National Forest Plan was devised to focus on erosion control by building dams near reservoirs and areas prone to landslides.

Some of the erosion control measures include: hillside slope grading; terracing; soil fixation structure; underground laying structure; small scale erosion dams; hillside drainage channels; hillside wickers; terrace sodding structure; mini-terrace sodding structure; strip sodding structure; slope mulching structure; contour trench method; seeding measure; and afforestation.

Figure 6: ***Forest Rehabilitation of the Devastated Forest Land in Seongingun, Gyeongsangbukdo, Korea***

Afforestation is the final stage of erosion control. However, top soil in denuded areas is infertile and the physical properties are inappropriate for tree growth. Accordingly, tree species tolerant to harsh environmental conditions should be carefully selected. The tree species suitable for soil conservation are Pitch pine (*Pinus rigida*), Siberian alder (*Alnus hirsuta* var. *sibirica*), Firma alder (*Alnus firma*), Woody lespedeza (*Lespedeza cyrtobotrya*), Bicolor lespedaza (*Lespedeza biocolor*), and Black locust (*Robinia pseudoacacia*). Native grasses and legumes were also used for soil conservation purposes by direct seeding on denuded hillsides.

On April 5, 1992, the National Reforestation Monument was built at Gwangreung National Arboretum to commemorate the 20th anniversary of the rehabilitation projects. Currently, Korean forestry is facing new challenges as policy priorities are changing. The focus on greening and rehabilitation is now shifting to forest resources management (http://english.foa.go.kr/).

2.2.2 Landslide Caused by Heavy Rainfall

Rapid devastation of forests induced by urbanization and industrialization, and torrential rainfall caused an increase of landslides resulting in many losses of lives and properties. Factors causing landslides are classified into artificial factors such as forest devastation and inappropriate land-use, and natural factors. Natural factors directly affecting landslide are heavy summer rain with more than 200 mm of continuous rainfall or 30 mm of rain per hour, and typhoons. Indirect natural factors are related to geographic and geological characteristics of the region such as steep slope, rough topography, or irregular soil layer. Especially areas with long, steep, and concave slopes, devastated forests, and ground water eruption have high landslide potential. Geographic and geological factors caused 90% and vegetation factors caused 10% of the landslides in Korea. A study showed that the depth of roots of vegetation which could prevent landslides was less than 1 m, and landslides occurred more often in smaller sized forest with less density. Artificial slopes are 5.7 times more vulnerable to landslides than natural slopes. Landslide occurrence by mud flow or debris flow is also increasing because of deeper soil layers that have built up under better forest condition and ground vegetation. The Korea Forest Research Institute developed landslide risk tables using 7 factors such as slope length and bedrock. Based on these data landslide risk maps were created with GIS techniques.

Landslide control works to reduce soil pressure, to control ground and underground water and to stabilize rocks are being tested. Erosion control dams are also being constructed. Forest management to control stand density and increase diameter is important to prevent landslides. Landslide hazard areas caused by forest devastation and inappropriate forest uses are treated with slope stabilization works such as retaining walls and drainage work.

The forest land in Korea is vulnerable to erosion disasters, especially landslides because of frequent attacks by typhoons and localized torrential downpours in summer, steep topography and geology consisting of igneous and metamorphic rocks. The landslide frequency has been increasing so that an area of more than 1,000 ha was damaged by landslides every year over the past decade. In particular, Typhoon Rusa in 2002 and Typhoon Maemi in 2003 caused numerous landslides on the east mountainous area of Korea inflicting serious damages. The recent rapid increase in sediment disasters on forest lands such as steep slope erosion, landslides and debris flows have been caused by frequent occurrences of high-intensity rainfall events triggered by global climatic change. Overall environmental change has also caused bigger forest fires and floating wood jams.

The countermeasures to prevent sediment disasters on forest lands consist of two types of measures, i.e. the construction of sediment control structures which can prevent the sediment runoff from flowing downstream and the establishment of an early warning and evacuation system for issuing warnings, with subsequent evacuation and rescue activities. However, the most important thing before the establishment of countermeasures to prevent sediment disasters is to set up a system for surveying and managing sediment disaster hazard areas. As of 2005, the number of areas being designated and managed as a sediment disaster hazard area has reached 525,307 in Japan but just about one hundred in Korea. Therefore, it is necessary that the management of sediment disaster hazard areas in Korea should be improved using the digitalized national landslide hazard map prepared in 2005 and execution of national-wide surveys of areas which are located under torrents and steep slopes and may be vulnerable to damages by sediment related disasters.

Forest practices such as thinning and pruning can be useful to prevent and minimize sediment disasters. Sound forest practices can lead to preserving and protecting a healthy forest environment which can be resistant to sediment disasters. In case of sediment control structures, an erosion control dam is the most typical and biggest structure which can trap a large quantity of sediments and check catastrophic sediment discharge such as a debris flow with landslides. In Korea, the construction of erosion control dams has begun seriously from 1986 onwards, so that in total 1,744 erosion control dams have been in operation as of 2005.

2.3 Forest-related Watershed Management for Restoration

A forest-related watershed management project has been implemented in the area damaged by the natural disaster in 2002 to reduce future risks for lives and property (Figure 7). Within a watershed all components of the landscape are included, i.e. matrix, patch and corridor. The input energy such as rainfall moves downstream through stream channels within the forested watersheds. The natural disaster in forested watersheds may be understood as a process that causes soil, rocks and debris to move downstream resulting in damages to lives and property. Traditional erosion control works usually focus on rehabilitation of the damaged land and stream, but on the other hand forested watershed management projects aim to prevent natural disasters from taking place in a specific watershed through several kinds of facilities like erosion control dams and revetments.

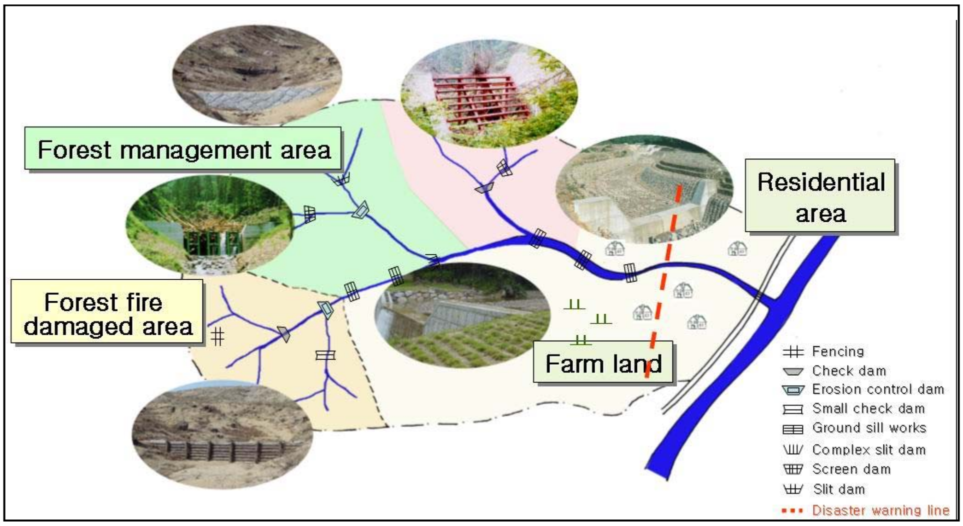


Figure 7: ***The Schematic Map of a Forested-Watershed Management System***

The forest uplands as matrix component of the watershed area are managed to maintain soil stability through forest practices such as thinning and pruning. Forest-fire damaged areas as patch are restored in an environmentally-friendly way. The stream channel as corridor is managed to establish the erosion control dam and several stabilization facilities. All above mentioned components must be systematically managed from the viewpoint of landscape ecology. Watershed areas with large villages downstream meet the conditions for the project because the importance of the project is high to save lives and property. In this project civil engineering structures like concrete and steel dams are established. In the future, in forested watershed management projects environmentally-friendly structures will be adopted rather than civil engineering structures.

2.4 Forest Fire

2.4.1 Restoration of Burned Area

Forest fire is one of the most important factors of ecosystem disturbance in Korea, because vegetation, insects and wild animals are affected on the ground. Forest fire occurred in 543 cases on annual average damaging 1,844 ha of forests in Korea every year. 70% of forest fires occur in spring time because spring is the windy and driest season in Korea. More than 80% of forest fires are accidental fires caused by mountaineers, tomb visitors and children, levee fires and cigarette butts.

For the restoration of burned forest areas Japanese larch (*Larix kaempferi* (Sieb. et Zucc.) Gordon), Korean white pine (*Pinus koraiensis* Sieb. et Zucc.), and Pitch pine (*Pinus rigida* Mill.) were planted till the 1980s. Continuous management of planted area resulted in successful stand establishment with 448 m^3/ha of stand volume of Japanese larch on proper sites such as valleys, and 295 m^3/ha of Korean white pine. However, natural regeneration by oak or black locust stands comprised only 174 m^3/ha of stand volume. Plantations seemed to be more appropriate for timber production when a stand was regenerated after fire. Oaks dominated on slopes with 174 m^3/ha of stand volume if there were no management activities. However, growth decreased as trees aged due to environmental stress such as soil nutrient and climate, and some trees had heart-rot in the lower stem and even in the upper crown area. Pine was naturally regenerated on ridges after fire and made it to mature stands with 422.5 m^3/ha of standing volume. Black locust recovered to proper stands which had black locust before fire if the management was continued.

Black pine (*Pinus thunbergii* Parl.), Korean pine, Weymouth pine (*Pinus strobus* L.) and Norway spruce (*Picea abies* (L.) Karst.) were planted in the 1990s and also the natural regeneration potential of these species was investigated.

A comparison of natural regeneration and plantation in the east coast fire area in 2000 showed that the level of soil erosion was high for the first 3 or 4 years after fire in both areas. Biodiversity in plantations was low at first and increased while natural regeneration areas had high biodiversity. Stand density was 1,300 trees/ha in natural regenerations and 1,700 trees/ha in plantations. Early growth rate was low in plantation, but high in a natural regeneration area if roots survived. Plantations had more harvest volume and were easy to manage. Both areas needed continuous management activities, and site preparation in plantation and early sprouting control in natural regeneration area were especially important. Plantation and natural regeneration should keep pace with each other depending on the site characteristics. Plantation was generally favored in post fire regeneration for timber production. However, species selection and tending should be carefully considered. If sprouting is sufficient, tending after natural regeneration is favored.

Fire damaged areas show rapid loss of nutrients. Loss of organic layer by fire increases soil erosion, which requires soil erosion control such as soil arresting structures to prevent soil loss and enhance early regeneration. Removal of damaged trees by fire should be implemented parallel to contour lines to slow down water flow and prevent soil erosion. If Red Pine survives, fairy rings of Pine mushroom (*Tricholoma matsutake*) may appear being a very important income source for rural residents or farmers. Pine mushroom production would then be viable in 5 to 10 years except pine trees are affected by a second damage.

For more effective forest fire control, Korea has expanded suppression facilities and equipments as well as increased the number of fire suppression crews. Also, forest fire prevention campaigns are conducted twice a year together with preventive measures such as building watch towers and setting up surveillance cameras. More importantly to modernizing suppression facilities, KFS will secure state-of-the-art equipments including medium-size, large-size and super-size helicopters (http://english.foa.go.kr/).

2.4.2 Restoration of Forest Fire Damaged Sites after East Coast Fire in 2000

The East Coast Fire in April 2000, which resulted in 24,000 ha of forest burned, brought a social debate between traditional foresters who insist on traditional post fire restoration of artificial regeneration and environmentalists who insist on natural regeneration. Traditional forestry was criticized and experts and local organizations participated in the 5-year forest restoration plan of the Korea Forest Service. The plan was established with the combination of natural regeneration and artificial planting, i.e. 48.5% of fire damaged area was restored by natural regeneration, and the others (51.5%) by artificial planting. Containerized red pine seedlings were planted in the coastal mountainous area, while in the inland mountainous area in the east coast fire region additional site preparation measures before planting of containerized red pine seedlings were necessary. Emergency restorations, erosion control, restoration for Pine mushroom (*T. matsutake*) were the main restoration objectives in 2001. The restoration strategy of the east coast fire damaged region can be summarized as detailed below:

1) Focus on ecological restoration methods.
2) Harmonious combination of natural and artificial regenerations.
3) Rapid restoration of landslide hazard areas.
4) Direct seeding or planting of containerized tree seedlings of Red Pine for pine mushroom (*T. matsutake)* production.
5) Natural restoration of areas where crown layer is alive, or habitats for specific animals or plants.
6) Restoration for scenic values.
7) Most appropriate restoration should be applied.
8) Building of forest roads should be decided based on policy decisions.

Post-fire restoration is using natural or artificial methods depending on site conditions and management goals. Not only efforts to restore fire damaged areas but also more efforts for the prevention of forest fires are required.

2.5 Conservation and Restoration of the Baekdu Daegan Mountain System

It is well established that the forest is a home to various living creatures interlinked by the food chain. Due to the geographical characteristics of the Korean peninsula stretching from north to south along with its topographic complexity, there are wide variations in temperature and rainfall which create a diverse flora and fauna. Although rapid industrialization over the past thirty years has devastated Korea's ecosystem, significant pockets of biodiversity have remained and need urgent protection. Korea gives a great deal of importance to wildlife conservation creating protection areas for wildlife and reserving parts of the national forest for scientific research. The protected areas cover over 2 million ha. More local and national arboretums, museums, and eco-forests are to be established nationwide to provide special protection for superior genetic resources. As of 2004, there are 35 arboretums, 6 forest museums, and 14 eco-forests. By 2007, additional 7 arboretums, 6 forest museums, and 3 eco-forests will be established.

One of the main efforts can be found in the preservation of the Baekdu Daegan Mountain System (BDMS). The Baekdu Daegan Mountain System (BDMS) is the most important of a series of mountain ranges forming the backbone of the Korean peninsula's topography. Conceptually, it came from the traditional perception of Korean people on the topographic feature of the Korean peninsula. Consisting of the major mountains, it stretches around 1,400 km from Mt. Baekdu down to Mt. Jiri. In South Korea, it is 684 km long with elevations ranging from 200 m to 1,915 m. In the Republic of Korea, 684 km of BDMS cover 9 national and provincial parks and encompass 6 provinces. The ecological significance of the BDMS cannot be overstated. Serving as the principal habitat for wild fauna and flora, 1,326 species which are 33% of the total 4,071 plant species in Korea, grow in BDMS including 10 endangered and protected species.

The BDMS is important not only as a topographic backbone but also as a major source of various ecosystem goods and services including forest products, clean water, biodiversity, tourism, and landscape scenery. However for several decades, Korea has experienced rapid industrialization. In this process, the BDMS forest ecosystem had been severely fragmented and its quality deteriorated. Various development activities have taken place throughout BDMS, including 72 paved and unpaved roads, 5 railways, 12 mines, and 6 dams.

With regard to this matter, the Republic of Korea formulated the Act on the Protection of BDMS on December 30, 2003, and it came into effect on January 1, 2005. The Act aims at establishing connectivity of the whole BDMS to ensure the maintenance of fundamental landscape and ecosystem services by protection and restoration of the area. The protected area consists of Core and Buffer Zones, so as to ensure the connectivity of the ecosystem without fragmentation and ecological restoration of the devastated area. The total designated area is 263,427 ha which covers 2.6% of the total land and 4% of the forest area of the country.

BDMS protected areas were created based on the Act. However, local communities protested against such action. The government put much effort in eliciting public consensus and understanding of the underlying criteria and principles in creating protected areas. Furthermore, assistance for local income projects were provided for the residents in BDMS protected areas. Along with this, the government purchased private properties that are included in the protected areas to minimize resident inconvenience and complaints (http://english.foa.go.kr/).

To achieve the goal of the Act effectively, implementation strategies are established by stages on December 2005. The first stage (2006~2008) is for the establishment of a management framework for the BDMS. At this stage, legal institutions and organizations for effective management are reinforced. Basic survey on the ecosystem and forest resources as well as research framework should be developed, while establishing other general structures for resident assistance projects and land purchase systems. The second stage (2009~2012) is for setting up and implementation of the management system. The expertise for the management of BDMS needs to be developed and cooperative and participative relationship with the local residents should be built. Model rehabilitation projects and monitoring processes should be developed while implementing the actions for the protection of the BDMS. In addition, a framework for south-north cooperation should be facilitated. The third stage (2013~2015) is for restoration and enhancement of structures and functions of the BDMS toward effective conservation and sustainable forest management (KFS, 2005).

2.6 Future Changes of Geographic Ranges of Vegetation by Climate Change

Climate is an important determinant of geographic range for many species. Recent northward movements of species' range boundaries consistent with warming have been observed in birds (Thomas and Lennon, 1999), mammals (Payette, 1987), and butterflies (Dennis, 1993, Parmesan *et al.*, 1999). Parmesan *et al.* (1999) examined changes in the northern range boundaries of 52 species of European butterflies over the past 30~100 years, and found that 34 species shifted northward, 1 species southward and 17 species remained unchanged.

Air temperature in mountain regions changes with elevation at about 1°C per 160 m and changes with latitude at about 1°C per 150 km (IPCC, 1996). Grabherr *et al.* (1994) surveyed montane plants on 26 mountain communities in the Swiss Alps and compared species distributions to historical records. The rate of upward shift was estimated to be 1-4 m per decade. These movements were slower than the 8-9 m per decade expected based solely on the change in mean temperature over the last 90 years. In Korea, using the scenario of global warming of 2°C by 2100, the shifts of the potential ranges of the several native trees including *Camellia japonica*, which is an evergreen broadleaved tree, *Quercus mongolica* and *Abies nephrolepis* were predicted based on the thermal ranges of the species (Lim and Shin, 2005). The predicted changes in distribution ranges are significant towards the north in latitude, and towards the top of the mountains. Distribution ranges of trees in the warm temperate forest zone, such as *Camellia japonica* were predicted to expand about 2 times, and extend 100 m higher in elevation (Lim and Shin, 2005). Trees of the cool-temperate forest and sub-alpine forest zones were predicted to become confined to half of the current potential ranges. Since the forests in Korea are located mainly in mountainous areas, altitudinal shifts of the distribution ranges are also important factors. Thus, the vegetation in the sub-alpine zone will be mostly affected. Priority should be given to the conservation of the high mountain vegetation and species of the habitat ranges in anticipation of significant global warming. Kong (2005) suggested that some plant species vulnerable to global warming can be used as climatic indicators of high summer temperatures in Korea. The author mentioned that further research on bioclimatic ranges and adaptation abilities of plant species would be required to assess the possible impacts of climatic warming.

Other montane habitats are expected to suffer more effects from climatic change such as dieback of montane trees (Hamburg and Cogbill, 1988; Fisher, 1997). It seems that the alpine and sub-alpine forests are vulnerable to global warming and monitoring and that conservation activities would be needed for the communities.

Many forest vegetation zones are likely to be shifted after alteration of the structure and species composition in each forest stand as a result of changing competition capacity among species in the anticipated rapidly changing climate of the 21st century as described above. The changes in forest zones and forest stand structure and species composition might bring about significant changes of Korean landscape and forest biodiversity. Deciduous forests dominating in Korea consist mainly of oaks and would move northward and be substituted by broadleaved evergreen forest of the warm temperate zone under warmer climatic conditions.

However, it is doubtful that the tree species migration will be successful to such a rapid changing climate in the highly fragmented and topographically rugged landscape of Korea. In order to adapt to the rapidly changing climate for the conservation of biodiversity and sustaining forest productivity, it will be necessary to establish effective networks of protective areas which will allow for free movement of living organisms and to conserve vulnerable species in-situ and ex-situ. In addition, there is the need to apply a new planting and silvicultural system which considers the future changing climate, i.e. choosing planting species that are better adapted to warmer climate.

2.7 Factors for the Success of Restoration in Korea (Summarized from KFS 1996)

2.7.1 Socio-Economic Stabilization and Political Leadership

The President's strong interest and energetic involvement in the restoration project was a key factor affecting the success of the restoration projects in the 1960s and 1970s. Whenever the late President Mr. Park visited local areas, he expressed the importance and urgency of forest restoration and urged local governments to participate in the restoration projects. Large financial, material and labor resources as well as the general public's should be accompanied by clear political leadership. Fortunately, in the 1960s and 1970s, Korea had a relatively plentiful cheap labor force and the national financial resources increased gradually because of the successful first and second Five-Year Economic Development Plans of 1962-1972. Also the Saemaul Undong which promoted the general public's, especially rural people's work ethic and cooperation contributed to the success of the forest restoration projects.

2.7.2 Voluntary Public Participation

Since the end of the Korean War, the Korean government actively pursued the rehabilitation of forests with many kinds of forest projects, encouraged villagers to re-establish communal cooperatives, so called "San-lim-gye (a kind of forest community structure)" and introduced "Saemaul Undong" that was a nationwide peoples' movement to get rid of poverty and improve the environment. These initiatives were designed to revitalize the traditional spirit of cooperation and unity and became cornerstones to accomplish successful forest greening.

The Korean word "Saemaul" is a compound word of a Sae, which means newness and brightness, and Maul, which means village community. Undong means movement. Literally translated, the Saemaul Undong is a "New Community Movement". It is the Korean version of the integrated rural development program. The Saemaul Undong started in 1971 in all the villages of rural areas with three slogans: diligence, self-help, and cooperation. The major objectives of this new community movement were to improve rural living conditions, increase food production, increase farmer's income, and finally secure more stable economic growth. The Saemaul Undong had multi-stages in the implementation of the program, and many sub-programs were integrated into the Saemaul Undong. Although it was a top-down project that the late President Mr. Park involved personally, the program was implemented voluntarily by individual village people.

The reforestation and erosion control projects under the First and Second 10-Year Forest Development Plans were closely connected to this movement. Forest projects around rural communities were mainly implemented by rural people and this helped to increase farm income.

The Korean government designated the 5th of April as an "Arbor Day" in 1946 in order to encourage the general public's voluntary participation in tree planting programs. As the Saemaul Undong started in 1971, a nationwide reforestation campaign has encouraged the general public to plant trees themselves in the areas of their own selection and to nurture them. The KFS formulated the tree planting period from March 21 to April 20. Almost every Korean, *i.e.* students in schools, soldiers in military service, workers in factories, government officials, businessmen, social organizations, and villagers in rural communities, participated in the tree planting programs during this specific period throughout the country. All materials for the tree planting program such as seedlings and fertilizers were supplied through the administrative channels of the KFS. Forest officials were dispatched to each reforestation site to give technical advice.

The nationwide reforestation movement greatly helped to successfully restore denuded forest lands within a relatively short period. The major reason for the success of the nationwide reforestation movement was that the President's leadership and the social movement through the Saemaul Undong encouraged the general public's voluntary participation. The late Mr. Park participated in the Arbor Day Ceremony in forests every year and encouraged the general public to participate in the tree planting program. During the period of the 1st and 2nd 10-Year Forest Plans about 2 million hectares of forest lands were reforested.

2.7.3 Implementation of Forest Protection Policy

The Ministry of Agriculture and Forestry promoted three major forest policies right after the establishment of the Korean government in 1948. First, five trees planting for one tree cut; second, development of charcoal substituting firewood; and third, prevention of illegal timber cutting. After the Korean War, the government initiated the new timber certification system with the cooperation of the Ministry of Home Affairs and Ministry of Defense. However, this program did not succeed because of social instability and the lack of responsibility of government officials.

The forest protection system was strengthened and implemented more effectively as the social and political conditions stabilized in the 1960s. In 1961 the government enacted the "Forest Law" and the "Law of Illegal Forest Products". The regulations on the prevention of illegal harvesting of forest products and illegal shifting cultivation were strictly enforced. The government set up a more strict policy on the forest protection along with the implementation of the First 10-Year Forest Development Plan.

The major policy measures were as follows:

- During the period vulnerable to forest fire the major trails were closed and trespassing into forests was strictly controlled;
- Dry seasons including the spring season (March 1 to May 31) and the whole of November were designated as forest fire warning periods;
- Permission for timber cutting should be based on the forest management plan approved by the forestry authorities;
- Firewood should be collected in a given period under the guidance of forest officials and village leaders;
- Anyone who damaged forest land had to repair the damage at his/her own expenses;
- Each forest protection officer should patrol specifically assigned forest areas at least 15 days a month;
- The head of the local government had full responsibility for the protection of man-made forests.

In these days there were few illegal cutting cases in Korea because of the government's strict regulation on illegal cutting. Besides this regulation, the rapid economic development, substituting energy sources from wood to fossil fuels, and importing timbers from foreign countries helped to lessen the pressure on the man-made forests.

2.7.4. Other Factors for the Success

One of the major factors responsible for several failed reforestation and erosion control projects until 1961 was that there was no systematic national forest planning scheme. Therefore, the Korean government established the National Forest Planning Scheme in 1960s as soon as the social and political conditions became stabilized. The National Forest Plan facilitated the integration of the forest restoration projects into a systematic process.

The other factor affecting successful restoration projects was related to the modernization of forestry techniques and effective diffusion of these techniques. Also there was much international assistance.

Several international agencies such as UNKRA (the United Nations Korean Reconstruction Agency) and ICA (International Cooperation Agency) provided food as wages for reforestation and erosion control projects from the mid 1950s to the 1960s. Especially, the food provided by the Public Law 480 of the United States was distributed to rural people participating in forest works as a wage substitute.

The international assistance pattern was changed from food aid to technical assistance in the mid 1960s. UNDP (United Nations Development Program) provided the techniques of forest survey and assisted funding forest resources survey (including soil conditions) from 1964 to 1969. Later, this experience played a positive role in establishing a comprehensive national forest plan. The bilateral forestry technical cooperation project (technical forestry labor force training and demonstration of the cooperative private forest management) between Korea and Germany, which started in 1974, contributed to the progress of Korean forestry management.

2.7.5 Valuable Lessons of the Korean Experience

The most important lesson we could learn from the Korean experience may be that the restoration of denuded forest lands and forest protection is not an obstacle to economic development but could be a chance for economic development. Through the forest restoration policy the other sectors such as agriculture and industries could be stabilized simultaneously.

However, developing countries should deliberate the unique Korean social system when they want to adopt the Korean model. Korean people believe they are one ethnic group, so that the national identity is very strong. Furthermore, the Confucianism tradition influenced the general public’s social norms that gave a great credit to the political leaders and government at that time. As shown in the Korean experience the leadership both in community and nation is a very important factor for the success of forest restoration. The Korean experience may provide some useful insights to developing countries which are faced with similar situations like Korea in the 1960s and 1970s under the circumstance that international concern on the sustainable forest development has tremendously increased.

3. Research and Educational Capacity for Forest Rehabilitation in Korea

Korean forests have shown dramatic changes in their roles in environmental protection, economic activities, and well-being of Korean people. With increasing social interest and expectations toward the forests, the role of forest education and research becomes diverse and critical. The forestry education and research sector has the responsibility to promote the benefits of forests and to conserve the integrity of the forest ecosystem for the next generation. The development of forest education and forestry research will help to find solutions to the challenges that Korean forests and forestry are facing today. This paper provides a brief overview of higher forestry education in the past and in the presence as well as R&D for forest restoration in Korea, exploring also the future direction of forestry education and research.

3.1 Forestry Education and Research in Korean History

The forestry education and research in Korea has a long history. The Shilla Chonrak Moonseo (755), the archives documenting civil, geographic, and economic information of four villages in Shilla (57 BC - 935), recorded the number of trees of economic species in each village, indicating trees were one of the major taxable assets. The fact that trees were taxable products implied that silvicultural management techniques were developed with silvicultural instructions for villagers. Various records on forestry were found in the archives of the Chosun Dynasty (1392-1910). The government continuously informed the public about the bad impacts of shifting agriculture and prohibited shifting agriculture on upper slopes, while planting was encouraged (Park et al. 1997). Sanrimkyungje was a good example of forestry education and research in the early modern era in Korea. It was a comprehensive book for agriculture, forestry, and life in agricultural areas. The fifth chapter of the book provided silvics of useful tree species and various silvicultural techniques including seed collection, seeding, planting, grafting, and harvesting, as well as pest management techniques.

Korea got down to modern forestry education with the establishment of Suwon Agriculture and Forestry School in 1906. Suwon Agriculture and Forestry School became Suwon Agriculture and Forestry College, and later was merged into Seoul National University. When the Suwon Agriculture and Forestry School (later called Suwon Agriculture and Forestry Technical College) was first established in Suwon in 1906, a forestry program was included into the general agricultural program. In 1922, the forestry program was first separated from an agronomy program and expanded to an independent department named “Department of Forestry”.

Forestry programs in other schools went through similar development processes as the one at the Suwon Agriculture and Forestry School. At the beginning, the forestry programs were included in the general agricultural program, and later on developed into stand-alone programs under the Forestry Department. The Agricultural College including the Forestry Department as part of it, was merged into the University. After the Japanese colonial rule was over in 1945, the Korean government with a recommendation from the American military authority established a national university system. Most of the agriculture and forestry colleges were merged into national universities between 1946 and 1950. Forestry education programs were placed at the departmental level. Forestry education was also conducted in agricultural high schools, and colleges till 1980s. Forestry education in agricultural high schools decreased after 1980 and is hardly taught at high school level or is only included as part of other classes. Currently forestry education including forest rehabilitation and restoration is carried out in several training centers belonging to the Korea Forest Service or National Forestry Cooperatives Federation, and universities.

With gradual changes in the paradigm of agricultural education during the past two decades of the 20th Century, forestry departments tried to reorganize the educational programs to meet the rapidly changing social needs in the forestry sector. Most of the forestry departments changed names from Department of Forestry to Department of Forest Resources in the 1990s.

3.2 Educational Systems at Academic and Technical Levels Offered by Universities

In Korea today twenty universities offer a forestry program at a departmental level, and two universities offer forestry programs at the inter-departmental level. Among the universities offering forestry programs at a departmental level, 12 universities are national, and 8 are private (see Annex 1).

NGOs are also involved in environmental education which includes reforestation and forest restoration issues. Korean NGOs such as Forest for Life, Korean Federation for Environmental Movement, and Green Korea occasionally organize seminars or workshops for the public, and the topics sometimes include reforestation and forest restoration issues. The Green Camp organized by Yuhan-Kimberly since 1988 is the forest education program for the public, especially for students. Since 2003, forestry departments in universities operate public extension programs funded by the Green Fund. The program includes forest ecology and restoration issues.

3.3 Forestry Research

Although the beginning of forestry activity and research in Korea dates back to an older historical period, modern forest research was initiated in 1906 when the Suwon Agriculture School (the former of the College of Agriculture and Life Sciences of Seoul National University) was established on the basis of modern forestry education. Since then, two major entities – universities and forest research institutes – have conducted forest research activities. The forest research institutes in Korea are mostly public, and organized by the central or local governments. The Korea Forest Research Institute (KFRI) is the most prominent forest research institute in Korea run by the central government. Local governments have local forest research institutes, one in each province.

KFRI was founded in 1922 as the Forest Experiment Station. In the beginning, the Forest Experiment Station focused its research on forest inventory, and dissemination of seeds and seedlings for afforestation (KFRI 2002). Since the establishment, the Forest Experiment Station has been enlarged and was finally reorganized as the Korea Forest Research Institute (KFRI) in 1987 with 3 Departments (i.e. Department of Forest Protection, Department of Forest Management, and Department of Silviculture) and 2 Experiment Stations (Central and Southern Forest Experiment Station). On the other hand, researches on tree breeding in Korea were initiated in 1956 when the Suwon Tree Breeding Branch Station was established under the Forest Experiment Station. At that time, hybridization and selection breeding were main research subjects. In 1963, the Suwon Tree Breeding Branch Station was separated from the Forest Experiment Station and reorganized as the Forest Genetics Research Institute with 3 divisions. In 1998 when the economic crisis hit the whole nation, the Forest Genetics Research Institutes were merged into KFRI as the Department of Forest Genetic Resources (Korea Forest Research Institute, 2006).

In 1960, the Korean Forest Society (hereinafter KFS) was founded. The KFS is Korea's first academic society in the field of forest and forestry sciences which has made a great contribution to developing forest science and technology. The KFS publishes 7 issues of the Journal of Korean Forest Society and holds 2 symposiums each year. When it comes to citation frequency, the Journal of Korean Forest Society has the highest impact factor in the field of forest and forestry science in Korea.

The examination of the number of published papers of the Journal of Korean Forest Society in different research subjects showed the change of hot issues in forestry over time (Figure 8). The classification of research subjects followed IUFRO's divisions, i.e.

1) Silviculture,
2) Physiology and genetics,
3) Forest operations,
4) Inventory, growth, yield, quantitative & managerial sciences,
5) Forest products,
6) Social, economic, information & policy sciences,
7) Forest health, *and*
8) Forest environment.

From this review, we can trace the temporal change of the subjects of forest research.

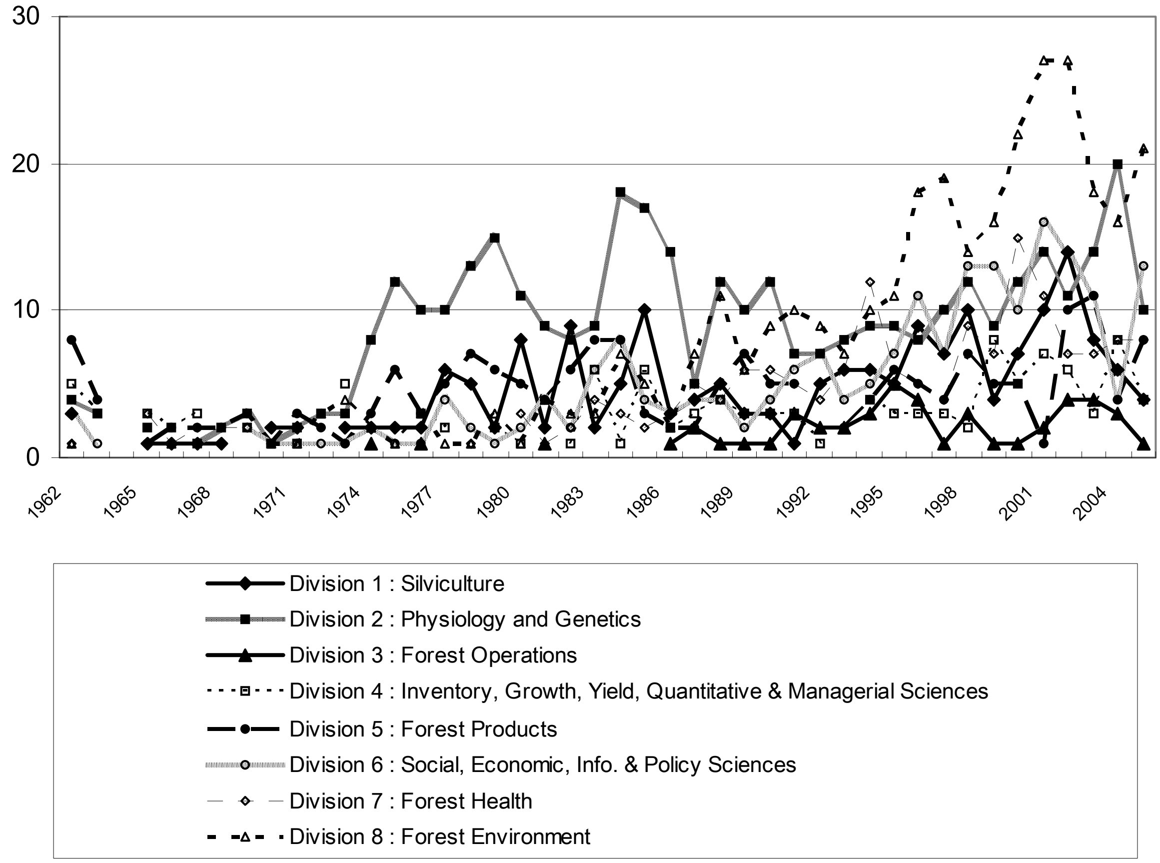


Figure 8: ***Change of the Number of Papers of the Journal of Korean Forest Society for Different Research Subjects. Divisions correspond to those of IUFRO (adapted from Shin 2006)***

The Division of Physiology and Genetics which had played a leading role until 1990 was replaced by the Division of Forest Environment since then. The change of prominent divisions in publications reflects the change of the public's demands on forest and forestry in Korea. The increased income allowed the public to become interested in forest recreation activities and became fully aware of the important role of forest in the creation and maintenance of sound environmental conditions, resulting in a rapid increase in research on forest environmental issues. Figure 9 shows the change of the percentage of published papers for each Division during a 10-year period.

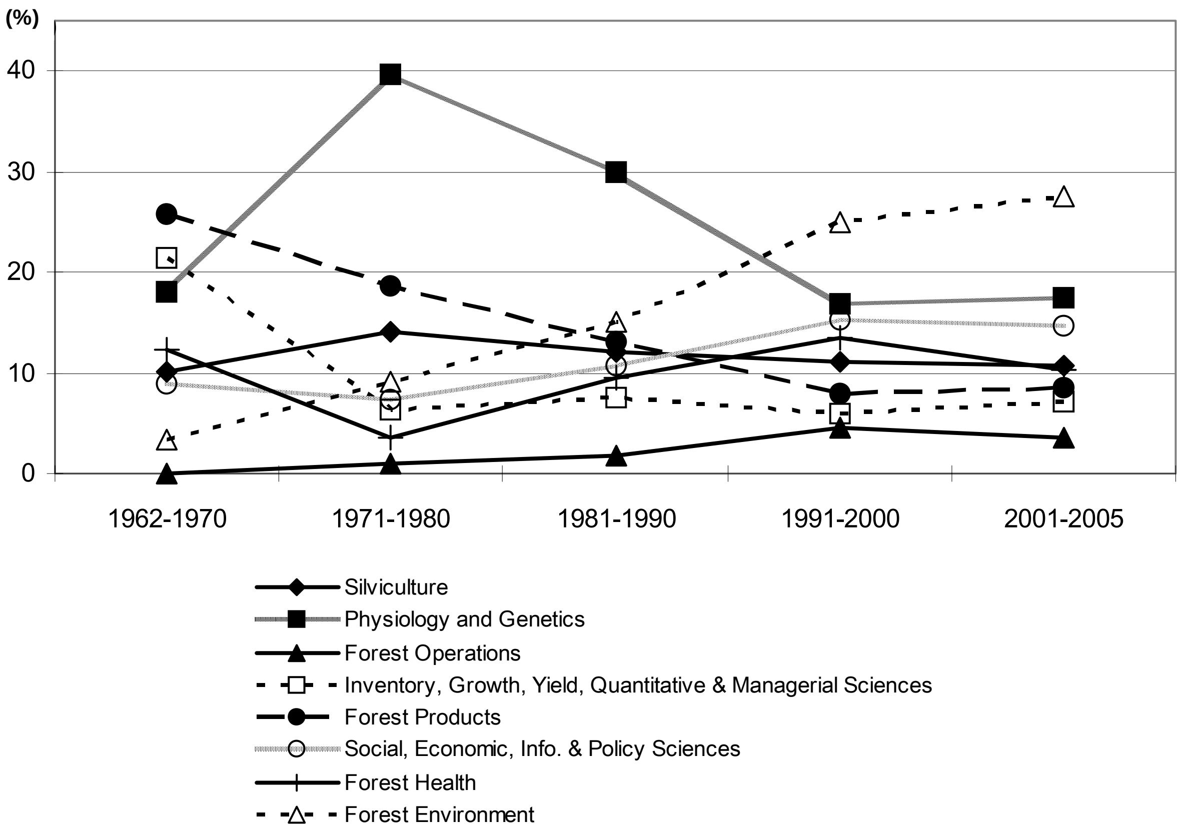


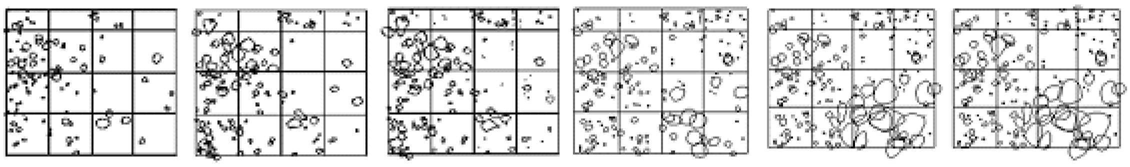
Figure 9: ***Change of the Number of Papers Published in the Journal of Korean Forest Society for Each Division by a 10-Year Period (Adapted from Shin and Lee 2006)***

3.4 Research Activities on Post Forest Fire Restoration

Korea focuses its research efforts largely on forest restoration after fire because forest fire is the representative stand replacing disturbance in Korea. The Goseong fire event in 1996 was especially a turning point in the history of forest restoration research in Korea. Post forest fire restoration became a major research topic after this fire involving many research groups.

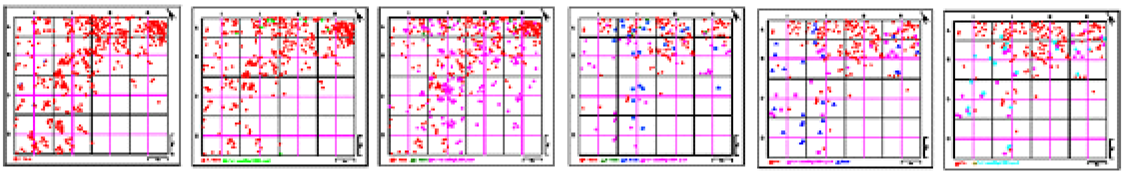
After the large-scale forest fire in Goseong, many people were interested in the effect of forest fire on the ecosystem and the method of restoration. A 100 ha long term ecological research site was installed in Goseong for the investigation of the fire effect on ecosystems (i.e. soil erosion, water quality, vegetation and wildlife). After a big fire named "Eastern Coastal Fire 2000", about 4,000 ha of a new LTER site in Samcheok, Gangwon-do, Korea was established. On this site, almost all kinds of research activities related to forest ecology and silviculture are addressed including forest meteorology for light regimes under mountain climate, vegetation changes, insects, birds and small mammals, soil productivity, erosion control and its effect on reducing post-fire erosion, hydrological influence, characteristic of fire damages according to stand structure and forest stand control to build fire resistant forest stands.

Sediment runoff was very intense in the first year after a fire event but reduced to natural levels in the third year. Water quality was restored in the year following the forest fire. Recovery of tree species progressed through sprouting of *Quercus* spp., and the recovery of herbaceous was perennial. Figure 10 and 11 show that the canopy density of sprouted regeneration gradually increased in the permanent research plot, while seedlings of *Pinus densiflora* decreased. The number and species of insects increased at the beginning, but decreased gradually later on. The number of bird species decreased after fire and recovered to a limited number of species which live in grasslands. Pine mushrooms have not yet recovered after the fire.



2001 (6 %) 2002 (12%) 2003 (13%) 2004 (26%) 2005 (29%) 2006 (32%)

Figure 10: ***Annual Changes of Sprout Coverage (%) in Samcheok***



2001 (477) 2002 (372) 2003 (426) 2004 (172) 2005 (152) 2006 (196)

Figure 11: ***Annual Changes of* Pinus densiflora *Seedlings in Samcheok***

The R & D budget in Korea has been increased continuously since the 1990s (National Science & Technology Council and Korea Institute of S & T Evaluation and Planning 2005). For the past 6 years from 1999 to 2004, the annual R & D budget increased by 13.3% on average. The largest amount of R & D budget was allocated to government-funded research institutes (43.4%), followed by universities (22.1%), medium and small sized businesses (12.7%), national and public institutes (6.8%) and large sized businesses (4.1%). In 2004, the amount of R & D budget for Agriculture, Forestry and Fishery was 3,832 hundred million Won which accounted for 7.2% of the total of R & D budget and ranks 4th following that of Information Technology (12.1%), Electrical Technology (10.2%), and Mechanics (8.3%). However, the percentage of the R & D budget for Agriculture, Forestry and Fishery has been continuously decreasing for the past three years, mainly due to the reduction of R & D investment in the agriculture sector.

In addition to governmental support for forest education and research, NGOs have supported the activities for reforestation and restoration. Since 1984, the “Keep Korea Green” campaign is a representative reforestation and restoration activity led by Yuhan-Kimberly, a private company (Yuhan-Kimberly 2007). Yuhan-Kimberly has also supported environmental research especially related to reforestation and forest restoration since 1996, publishing reports, booklets and books.

3.5 Future Education and Research in Forest Restoration

Forest education and research in Korea in the 1960s and 1970s focused on rehabilitation. As the Korean forest was fully rehabilitated in the 1980s and the Korean economy developed, the demand for fully functioning forest ecosystems increased, complying with a changing focus of research on forest restoration and forest functions, making forest restoration a hot research topic in the 21st Century.

In the 1990s nature conservation and environmental forestry became critical issues in Korea. Societal demands on forestry are changing with rapidly evolving social needs. To meet the demand for state-of-the-art knowledge and skills in forestry consultation, forestry education needs to follow the rapid changes in technology, and thus should be focused on integrated knowledge and practical experiences in forestry-related fields and societal demands. The curriculum is changing regularly according to the international trends. Current topics related to forest restoration include biodiversity conservation, carbon issues related to climate change, combating desertification, restoration and agroforestry activities related to poverty alleviation, greening of urban areas and gardening, laws and certificates related to international trade and environment, energy forestry and so on. Courses in graduate schools need to be strengthened by including new subjects and by recruiting faculty members with specific knowledge on new fields.

Wood production becomes of minor importance in the 21st Century over ever-increasing international concern on environmental forestry. Instead, environmental benefits of forests are more appreciated in recent days and accordingly, indirect benefits of forests, such as soil conservation, maintenance of biodiversity, and supply of clean air and water, are more recognized than wood production. Forest recreation and wildlife conservation are other areas of interest in the modern world. Again, to fulfill the societal demands for diverse forest functions, forest restoration seems to gain in importance.

Current forestry research in Korean is more focusing on multiple-use forestry to meet both direct and indirect benefits of forests. Sustainable forest management (SFM) is another paradigm in forestry for sustainable production of various benefits of forests in the long run (KFRI 2004b). With rapid increase in the population in big cities, clean water will be another hot issue and be in short supply in the near future. Wildlife has been much neglected in Korea due to mass destruction of forests during the Korean War in the 1950s leading to a rapid decrease in wildlife populations. With the recent rapid recovery of forests, wildlife has gradually come back and has attracted much interest from urban people who have started to appreciate the values and beauty of wildlife in the forest. Korea has a very short history of wildlife conservation. Wildlife habitat should be actively managed to enhance both health and productivity of the forests and wildlife at the same time. Research is needed to manage the forests to promote wildlife populations without damaging the forest environment for wood production and other benefits of forests.

Urban forestry will become more important in the future in view of gradual decrease in the urban green spaces. Green spaces with close-to nature and energy-saving landscapes as part of urban forestry would be an alternative to the current energy and labor demanding landscape. In this sense basic principles of forest ecology, forest succession, and natural balance of vegetation need to be applied to maintain urban green spaces. Research will be needed to promote healthy forests with balanced budgets in energy and material cycles, and without gradual decline of urban ecosystems through air pollution and soil contamination.

To do this, not only interdisciplinary but interdepartmental research is urgently required supported by GOs, NGOs and private sectors. Exchange programs for faculty members and students among universities, institutes and companies nationally and internationally will help the Department to be more active and stronger, thus maintaining leadership in forestry research and education.

4. Acknowledgements

The authors would like to thank Dr. Kyong Ha Kim, Dr. Jong Hwan Lim, Dr. Ho Joong Youn, Dr. Won Il Choi, and Dr. Young Geun Lee of the Korea Forest Research Institute for preparing material and data for this paper.

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Annex 1: ***List of Universities Offering Forestry Programs in Korea***

Korea University and Joongbu University which have inter-departmental programs are not included in the list (adapted from Kim 2006).

University	College	Department	Major
National Universities			
Kangwon National University	Forest Science	Forest Resources	Forest Resources Production
		Forest Resources Management and Landscape Architecture	Forest Management
Kyungpook National University	Agriculture and Life Sciences	Foresty and Forest Product Engineering	Forestry
Kyungsang National University	Agriculture and Life Sciences	Forest Science	Forest Resources
Kongju National University	Industry and Science	Forest Resources and Landscape Architecture	Forest Resources
Sangju National University	Life Resources Science	Forest Resources	
Seoul National University	Agriculture and Life Sciences	Forest Sciences	Forest Environmental Sciences
Sooncheon National University	Agriculture and Life Sciences	Forest Resources and Landscape Architecture	Forest Resources
Chonnam National University	Agriculture and Life Sciences	Forest Resources and Landscape Architecture	Forest Resources
Chonbuk National University	Agriculture and Life Sciences	Forest Science	
Chinju National University		Agriculture	Forest Resources
Chungnam National University	Agriculture and Life Sciences	Environment and Forest Resources	Forest Environment and Resources
Chungbuk National University	Agriculture	Forest Science	Forestry
Private Universities			
Konkuk University	Life and Environmental Sciences	Life Resources and Environmental Sciences	Forest Environmental Sciences
Kyunghee University	Life Sciences		Ecosystem Engineering
Kookmin University	Forest Science	Forest Resources	
Daegu University	Natural Resources	Life and Environment	Forest Resources
Dongguk University	Life Resources Sciences	Life Resources Sciences	Forest Resources
Sangji University	Life Resources Sciences	Forest Science	
Yeungnam University	Natural Resources	Natural Resources	Forest Resources
Wonkwang University	Life Resources Sciences	Biology and Environmental Sciences	Forest Resources

Accomplishments and Challenges of Reforestation in Japan: 140 Years of History after the Meiji Restoration

Nagata Shin[1]

Today two thirds of Japan's land area is covered with forests. One of the main reasons is the humid climatic conditions which are common to any of the per-humid Asian countries. However, not all of the Asian countries with such climatic conditions favoring tree growth enjoy rich forest coverage. Even in Japan, the high ratio of forest area has not always been the case in the country's long history. At the time of the Meiji Restoration which marked significant political and social changes in Japan in the mid 19th Century, treeless mountains were common. After the Meiji Restoration, Japanese people tried hard to increase the land area covered by forests. Unfortunately, we do not have statistics to show how this greening process had taken place.

At the time of defeat in the Second World War, a considerable proportion of the land in Japan was treeless, due to over cutting during the war. Japanese people again made efforts to reforest these treeless areas. Thus in Japan's recent history after the Meiji Restoration, there were two reforestation periods, some time before and soon after the Second World War. Today, 40% of the forests in Japan are man-made plantations and the rest is natural forest, most of which has naturally regenerated through silviculture activities after gathering fuel wood.

In this report I will describe these two reforestation periods. The first three sections of this report are devoted to the period before the war and the latter three sections are dealing with the period after the war.

Ownership of the land is fundamental to the success of any reforestation activity. Without clear ownership, i.e. who is responsible and willing to plant and manage trees, it is not possible to carry out reforestation activities. Thus, the first section describes how Japan established forest ownership. Since reforestation efforts differ according to different types of forest ownership, the second section deals with reforestation programmes in the National Forest. The third section is about the management of private and communal forests. In the period after the war, reforestation and afforestation were carried out mainly for establishing new forests for timber production. Thus, it is important to understand how the demand and supply of timber has changed over time. This is explained in the fourth section. The fifth section describes how the legal system has developed. The overall consequences for and changes in Japan's forest resources are detailed in the sixth section. The last section provides a summary of the major issues addressed in this report.

1. Establishing a Forest Ownership System in Japan

In the early days of its reign, the Meiji government revised the land tax system which was inherited from the Tokugawa feudal regime. As its most important component of the revision, certificates of land ownership for each parcel of land were issued attesting not only the ownership of the land holding but also the obligation of tax payment. The government issued the Land Tax Revision Decree in 1873, set up the Land Tax Office in 1875, and completed issuing the certificates for housing sites and cultivated fields by 1877.

Difficulties, however, arose when the government tried to issue such land-ownership certificates for forests, since the factual ownership of forest land was not well developed and the situation was rather complicated. It took much longer to complete issuing land-ownership certificates for forests and uncultivated fields, and the office closed in 1881.

At the time of the Meiji Restoration, the forests were owned and managed in the following three ways: Firstly, feudal lords, including Tokugawa Shogunate utilized their forests mainly for timber production and in some cases also planted timber trees. As a rule of feudalism, land and peasants were legally owned by feudal lords. Thus, those lands not utilized or claimed by anyone were considered property of feudal lords.

[1] Professor, the University of Tokyo

The second type of land ownership was those by individuals. Especially in economically advanced regions, wealthier samurais (warriors), merchants, and peasants invested their earnings into tree plantations and established factual ownership. This kind of forest ownership was relatively easy to identify similarly to the case of cultivated land.

Troubles arose in the case of the third type of ownership, namely forests utilized by rural communities. There were more than 70 thousand such communities and villagers commonly utilizing their forests for gathering fuel wood and other commodities for daily uses and thus factually owning these forests. The level of this utilization was not so intensive and it was hard to demarcate these communally utilized forests from those areas not owned by anyone. Partly because of the difficulty of identifying the boundaries of these communally utilized forests, it is very hard to quantify the extent of these forests in terms of area. However, it would not be far off the mark to estimate that about one third of total forest at the time of the Meiji Restoration was commonly owned and utilized by villagers.

In principle, these communally utilized forests were assigned ownership to villages. In reality, however, written evidence was required to testimony communal utilization, which is rather rare, and in many cases ownership was assigned to the national government.

We call this whole process, including issuing private land certificates, “classification of national and private forest” (see Figure 1).

2. Development in National Forest before WWII

After establishing the boundaries of the National Forest through the classification of national and private forest land, in 1890, the government started surveying the National Forest in order to demarcate “need-to-keep” forest and “not-need-to-keep” forest. “Not-need-to-keep” forests were disposed off to raise revenue for the government.

As described above, many communally utilized forests were assigned to the national government and local people had difficulties in utilizing these forests to gather fuel woods and other products. In 1899, the government issued the Law on Disposing National Forest and Uncultivated Field to accept petitions. The petitions were allowed to file only for one year, but there were 20,675 petitions requesting 2,070,00 ha of national forest to be re-designated to communal forests. Though the government issued the law in order to deal with the discontent of villagers, only 1,335 petitions were accepted.

In 1899 the government started the National Forest Special Management Project. It established a special forest fund for the disposal of “not-need-to-keep” forests. The Fund was also used for measuring “need-to-keep” forests, preparing management plans, planting trees and purchasing private forests. The Project was completed by 1922 accomplishing its initial objectives. Under the programme, trees were planted on unstocked areas within the National Forests amounting to about 300,000 ha. 750,000 ha of “not-need-to-keep” forests were disposed off, but acquisitions were made only for 2,000 ha.

The government accepted local people to plant trees in National Forests to share future harvests from these plantations. This kind of arrangement was intended to utilize the abundantly available workforce in rural areas to support the livelihood and income of rural communities.

3. Development in Private and Communal Forests before WWII

As mentioned above there were more than 70,000 villages, or naturally formed settlements, at the time of the Meiji Restoration which were institutionalized into administrative villages in 1889. This institutionalization took place in most cases with a consolidation resulting in about 12,000 institutionalized communities, named cities, towns and villages, according to the size of the communities. In many cases further consolidation was carried out around 1955. Today another consolidation process is taking place among the existing about three thousand villages, towns, and cities in Japan.

This process of consolidation further complicates the situation. Villages with a lot of forests were often merged with villages without forest land, and those with large forests did not want to merge their forest. Some of these forest-rich communities maintained their forest as settlement-owned, and others divided their forest into individually owned forest properties.

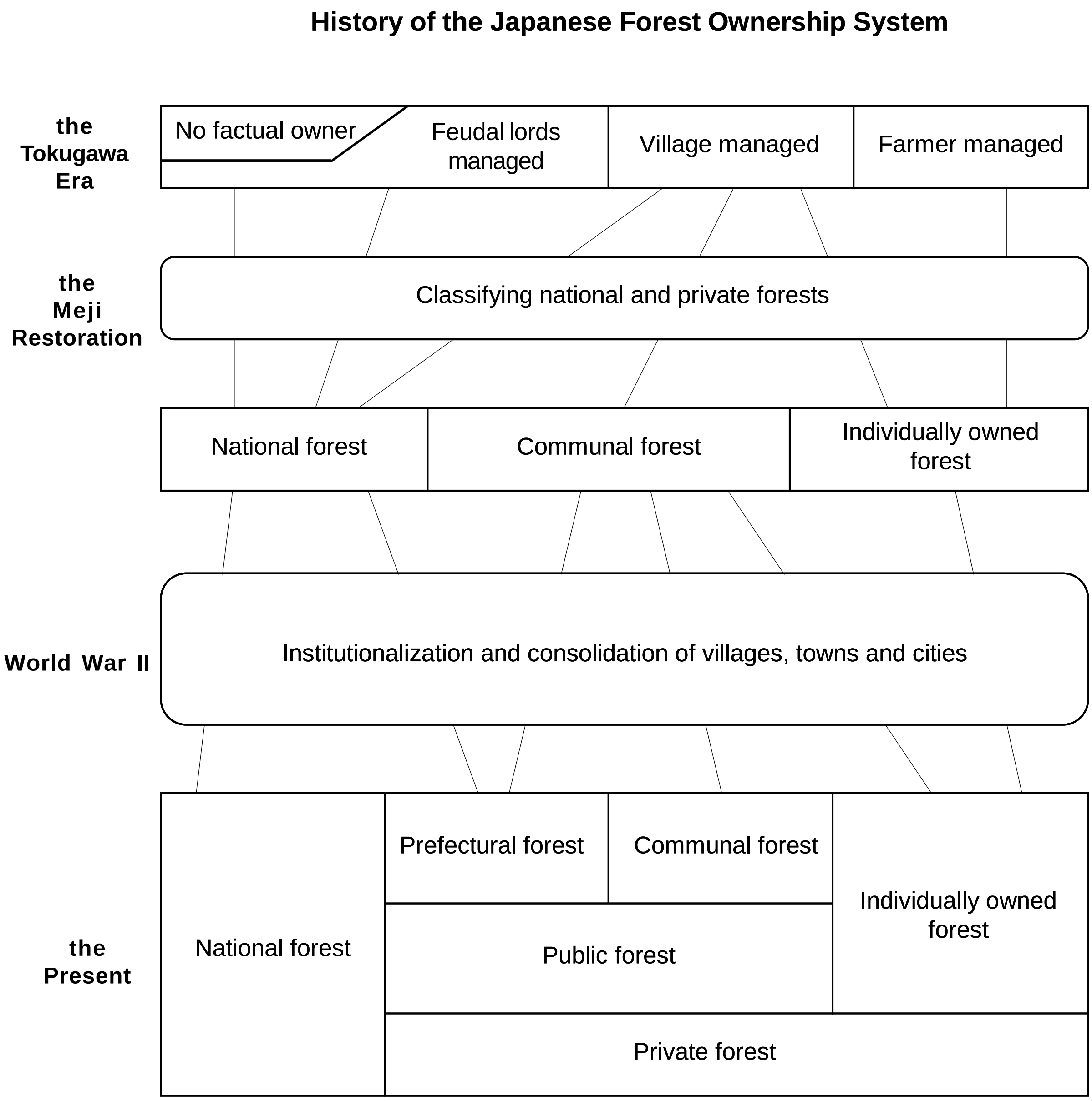

Figure 1: ***History of the Forest Ownership in Japan***

Because of this historical development of forest ownership, forests belonging to prefectures, cities, towns and villages are included in the category of "private forests" along with individually owned forest. Although these forests are referred to in Japan as "public forests", they are not national forests owned by the state. The government regarded these communal forests as uncontrolled. Because of communal arrangements, the management responsibility was unclear. Over cutting and over utilization were frequently observed resulting in a decrease of stocking volume of these communal forests. Towards the end of the Tokugawa Period and just at the beginning of the Meiji Period, communal rules were not well obeyed. Drawings of these periods show treeless mountains near human dwellings. Those mountains were probably utilized by villagers as communal land.

In the early Meiji Period, frequent floods occurred. The devastated mountains were identified by the government as the main reason for flooding. As a consequence, in 1896 and 1897, the government enacted three so-called flood-controlling laws, namely the Forest Act, the River Act, and the Soil Erosion Control Act.

The first Forest Act went into force in 1897, introducing protection forests and a forest policing system. Till today, the same protection forest system is in place although some amendments have been made over time.

The first law was abolished in 1907 and replaced by the Second Forest Act expanded by a forest owners' cooperative system to encourage the forestry industry. These cooperatives could be established upon prior agreement of more than half of the forest owners who own more than two thirds of the forest area in a municipality. Then, all the owners in the municipality had to join the cooperatives.

The most important amendment before World War II was that of 1939. All forest owners' cooperatives became compulsory with the obligation to manage the forest according to approved management plans. During wartime this combination of forest owners' cooperatives and management plans were the main tools for controlling forestry economy.

From 1910 to 1935 the first forest flood control project was carried out. This project aimed at restoring devastated communal forests covering a area of 60,000 ha.

In 1920, the Law of Governmental Plantation on Public Forest Land was enacted. Under this law forest plantations were established by the national government on "public forest" land, i.e. forests owned by municipal or communal authorities. The proceeds from timber harvests were shared equally between the national government and cities, towns or villages, respectively. This scheme was to help institutionalized communities by providing funds needed for planting trees. By the time of abolishing the Law in 1961, a total area of 330,000 ha of forest plantations was established, as intended.

4. Timber Demand and Supply

4.1 Timber Demand

Figure 2 depicts changes in Japanese timber demand after the Second World War. The Japanese timber market is characterized by rather small export share. Around 1960, timber export was an important component in wood panel production. At its peak, the export share of the wood panel production was 29% in 1959, whereas it was only 3% of the total timber production. Thus, we can neglect the export in explaining the timber demand in Japan.

In the early days, as can be seen from the 1955 figure, about one third of the total demand was for fuel wood. Consumers, especially in rural areas, heavily relied on fuel wood for their daily energy needs. However, in the 1960s they shifted their energy demand to electricity and propane and town gas. This led to a reduction in fuel wood demand. In the 1970s fuel wood became an almost negligible component of the total timber demand.

Lumber has been the major timber commodity basically driving the trend of total annual timber demand. About half of the housing construction in Japan uses lumber as main building material. Thus, when there is a lot of house construction, lumber demand is high. Lumber demand has steadily increased up to 1973, the time of the first oil crisis. From around 1955 until 1973 Japan's economy enjoyed rapid growth and construction demand was buoyant, which translated into a rapid growth of lumber demand. After that lumber demand has shown declines and increases basically following the highs and lows of the Japanese economy.

Wood panels follow a similar pattern compared to lumber, probably reflecting the fact that both timber components are used for construction purposes.

Pulp demand has shown a steady increase throughout the past, even after the first oil crisis. Pulp demand for manufacturing paper products largely follows the pattern of the national income. Thus, pulp and paper demand increases at the same rate as national income or GDP. Even after the first oil crisis, Japan's economy has had positive economic growth rates, except for a couple of years. Thus, after 1973 pulp demand even has increased during slower economic growth.

4.2 Timber Supply

Let us turn to the supply situation of the Japanese timber market (Figure 3). The supply of fuel wood coming almost entirely from domestic sources decreased in the early days, thus reflecting the decrease in fuel wood demand.

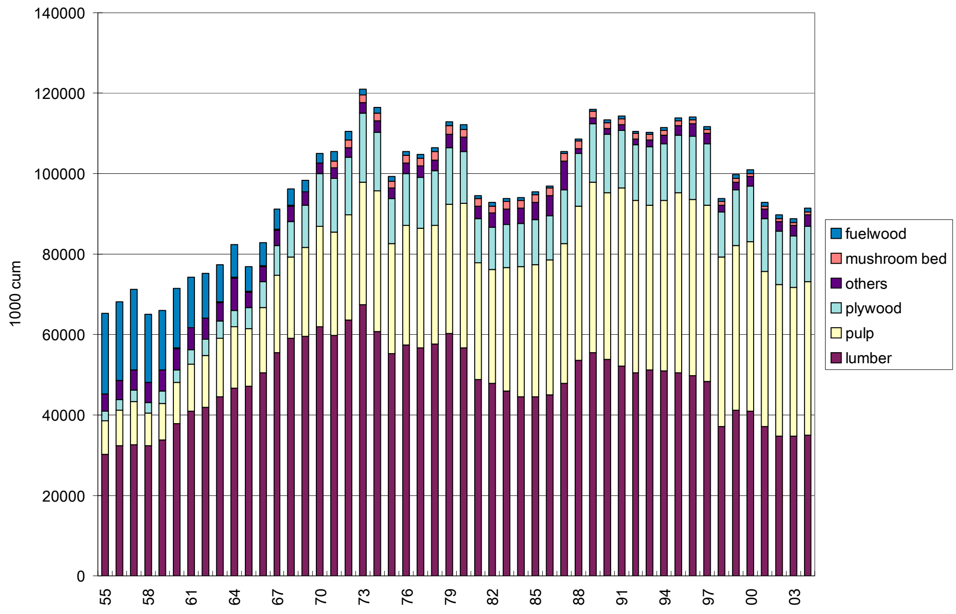

Figure 2: ***Changes in Wood Demand between 1955 and 2004***

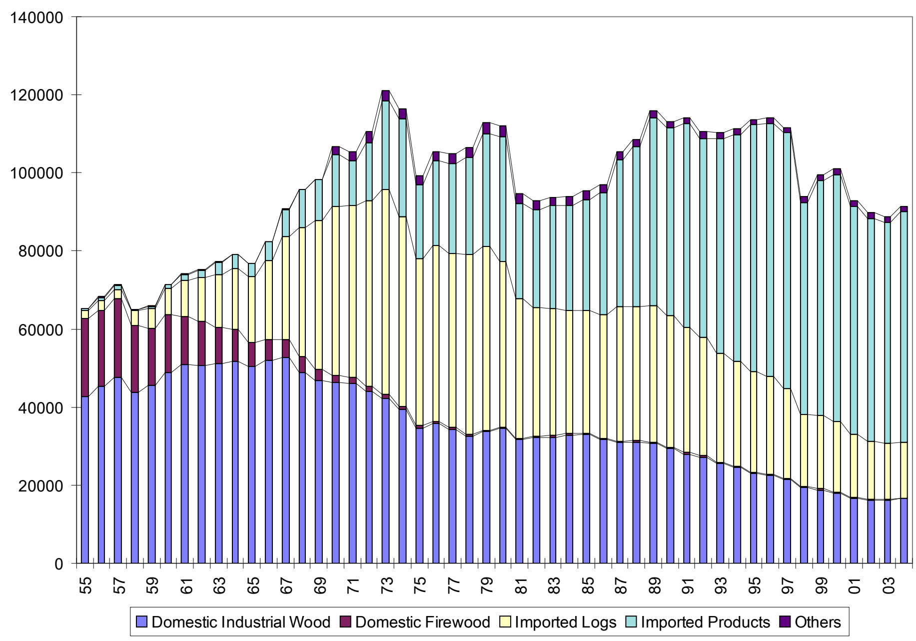

Figure 3: ***Timber Supply in Japan between 1955 and 2004 (1000 CUM)***

Domestic timber supply other than fuel wood increased up to 1967 and decreased thereafter. It is interesting to note that even though demand itself had ups and downs after 1973, domestic timber supply showed negligible fluctuations within a steadily decreasing trend.

The increase in demand up to 1973 and fluctuations thereafter were absorbed by foreign supplies. In the late 1950's, when timber demand for housing construction was strong, the government attempted to increase supply in three ways by firstly increasing timber production from the National Forest; and secondly by increasing future timber production by promoting afforestation. Forest trees were planted not only on unstocked areas, but less productive broad-leaved forests were transformed to more productive plantation forests consisting of Japanese cedar, cypress, and larch species. The third way was to increase import of timber. The timber trade was liberalized in the early days with tariffs on timber lowered and port facilities for timber imports improved. These policies were the main features of the so-called Timber Price Stabilization Policy introduced by the Cabinet in 1961.

Since then, Japan's economy gained momentum, more timber was imported, and labor wage increased. Although the increase in wages was a good sign for most people, it also meant increased costs for timber production. As a consequence, Japan's timber production lost competitiveness versus foreign imported timber with product imports increasing in the later days to replace log imports. These developments are a clear reflection of the forestry policies of an industrialized and export-oriented country.

5. Changes in the Legal System after World War II

Besides the Forest Law also the so-called Fundamental Law of Forest and Forestry and the Law of Forest Owners' Cooperatives are definitely the most important legal instruments in Japan's forest policy. In this report I will concentrate on the Forest Law, because it has a long history and has had many amendments which reflect concurrent states of forest policy. Elements of the Fundamental Law of Forest and Forestry and the Law of Forest Owners' Cooperatives will be mentioned in conjunction with the description of the Forest Law.

5.1 The Third Forest Law: Forest Planning System, Reorganization of FOCoop

After the defeat in World War II, democratization became the key issue for all reforms in the country. The old law was abolished and the third law was enacted in 1951. The old management plan system was repealed and a new forest planning system introduced, based on a hierarchical structure of national and prefectural plans. The management plans were designed to be prepared either by individual forest owners or by forest owners' cooperatives. Designing the forest planning system became the responsibility of the governments; the national plan was prepared by the central government and prefectural plans by the prefectural governments. Each individual forest owner had no obligation to follow the plans, but used the plans as guideline for their management.

Forest Owners' Cooperatives were reorganized to become voluntary entities. Only those who wanted to join the cooperatives participated in the cooperatives' organisation. In many cases, however, those cooperatives established before the war gained the forest owners' cooperatives status legalized by the Third Forest Law. The cooperatives were organized corresponding to institutional communities. Silvicultural subsidies for planting and tending trees were handled through the cooperatives.

5.2 Amendment (1968): Forest Management Planning System

There were several amendments to the Forest Law, and I believe three of them are worth mentioning. The first was that of 1968, when the Forest Management Planning System was introduced into the Forest Planning System. It should be regarded as a rebirth of the Management Plan System of the 1939 Amendment. It is, however, different in a very important aspect: It is voluntary! Today, the forest planning system has a hierarchical structure of national, prefectural and individual levels.

In 1968, the amendment was just four years behind the enactment of the Fundamental Law of Forestry. Both laws share the same background, i.e. Japan's economy started to grow briskly with an economic growth rate of around 10% since the late 1950s. This brisk economic growth meant two things to the forestry sector. Firstly, the gap of income between forestry workers and urban workers significantly widened and the government searched for a way to close the gap. And secondly, there was a strong demand for timber to rebuild houses that were damaged during the war leading to a rise in timber prices.

As mentioned above, the Timber Price Stabilization Policy was introduced by the Cabinet in 1961. To narrow down the income gap between forest and urban workers, the government enacted the Fundamental Law of Forestry. The objective of this law was to enhance the economic and social status of forestry and those working in this sector. The focal point of this policy was to build forest road infrastructure through forest road construction subsidies.

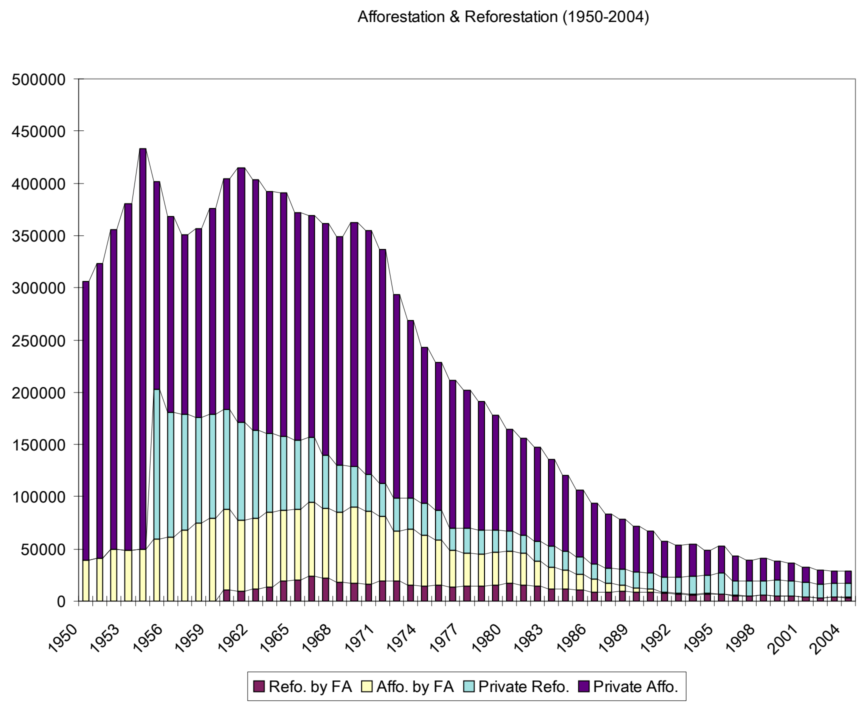

Figure 4: ***Afforestation and Reforestation between 1950 and 2004***

In 1978, the Law of Forest Owners' Cooperatives was enacted (see Figure 4). Rules regulating the cooperatives originally written in the Forest Law were separated and incorporated into this enactment.

5.3 Amendment (1974): Target Areas for Four Forest Functions

By 1973, the time of the first oil crisis, people became more aware of the importance of the natural environment, which was under threat after 20 years of rapid economic growth. At the same time, deficit in the National Forest Special Account became a steady feature of the National Forest Program. As explained above, Japanese forestry lost competitiveness in the Japanese timber market during the time of rapid economic growth in the late 1950s and 1960s. The situation was especially severe for the Forest Agency, because it employed quite a large labor force with semi-public servant status and it was hard to curtail the salary levels. The Forest Agency of Japan needed to redirect the objectives of its policy. The 1974 Amendment required the Forest Plan to list target areas for four forest functions, namely timber production, water resources conservation, hillside erosion control, and preservation of public health.

In 2003, the Fundamental Law of Forestry was revised to become the Fundamental Law of Forest and Forestry. This law was intended to enhance forestry through the recognition of the importance of the multiple functions of forests.

6. Changes in Forest Resources

Forest owner composition changed little in the period after the war. In the early days after the war, individual private holdings increased at the expense of village-owned forests. This was probably due to the consolidation of institutional communities. It is safe to assume that after the war, Japan's forest sector activities were carried out under a stable forest owner system.

Just after WW II, forests were devastated, and the country had a lot of treeless areas. The first goal, therefore, was to afforest these barren areas.

Because of increasing timber prices, afforestation became an attractive investment opportunity for peasants in the 1960s. They not only afforested non-forested area, but also transformed natural forests into plantation forests with species of higher growth potential, such as Japanese cedar and *cyprus*, namely *Cryptomeira japonica* and *Chamaecyparis obtusa*.

The statistics recorded in the early days did not separate reforestation from afforestation, until 1955 for private forests and until 1960 for national forests, respectively. Although no detailed information is available, it seems clear that reforestation on private forest land was quite active in the 1950s and the early 1960s (Figure 4). Afforestation, which includes not only plantation of treeless areas but also the transformation of less productive natural forests into more productive plantation forests, was carried out until early in the 1970s. Afforestation and reforestation totaled 300,000 ha in the early 1970s but has declined until today to about 30,000 ha only.

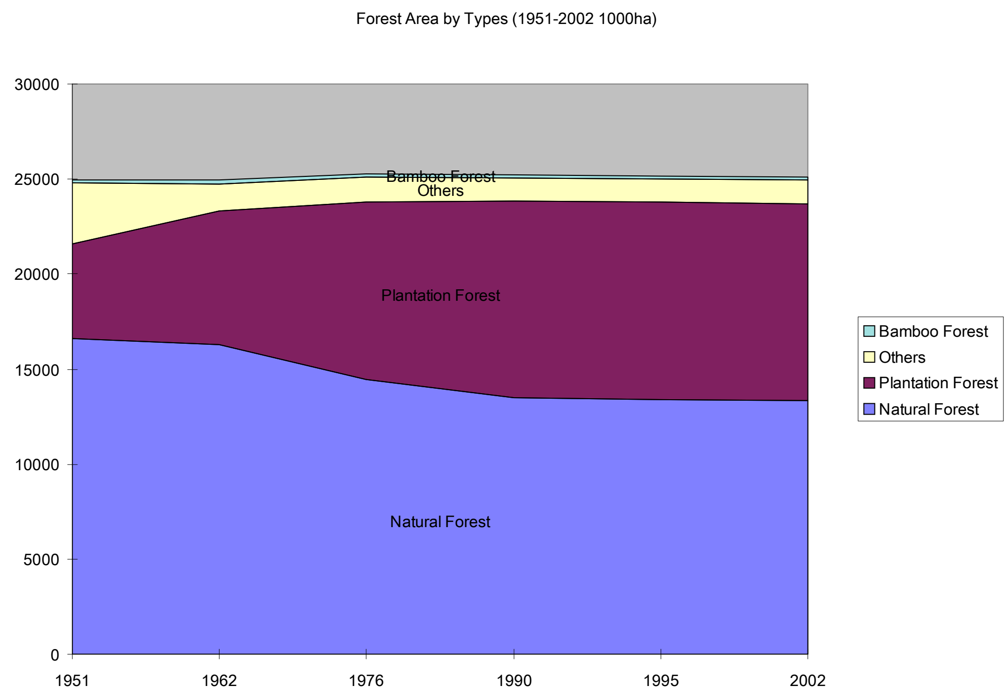

Figure 5: *Forest Area by Type*

Average Standing Stock

The average standing stock is often a good indicator of the quality of forest resources having increased dramatically in Japan in the postwar period (Figure 6). A closer look at the figures reveals that the increase was slow in the early days with accelerated increase later on. This was due to the fact that afforestation was taking place briskly, so that the average age of plantations was kept low, and hence the average standing stock at a lower level. Because today afforestation activities are carried out on a much smaller scale, the average age of the plantation is higher with a higher average standing stock, too.

The protection forest area remained rather stable from 1923 until the 1950s. As forestry activities are restricted in protection forests, forest owners did not want their forest to be designated as protection forest.

The protection forest area increased, however, very rapidly from late in the 1960s up to 1970. This increase was due to an increase in protection forests for water resources conservation. This was probably reflecting the increasing demand for water due to rapid economic growth. Until the 1950s there was little merit to forest owners to place a forest under protection. However, later on, silviculture subsidy rates for protection forests were increased and the government also provided a reduction of and exemption from taxes for protection forests.

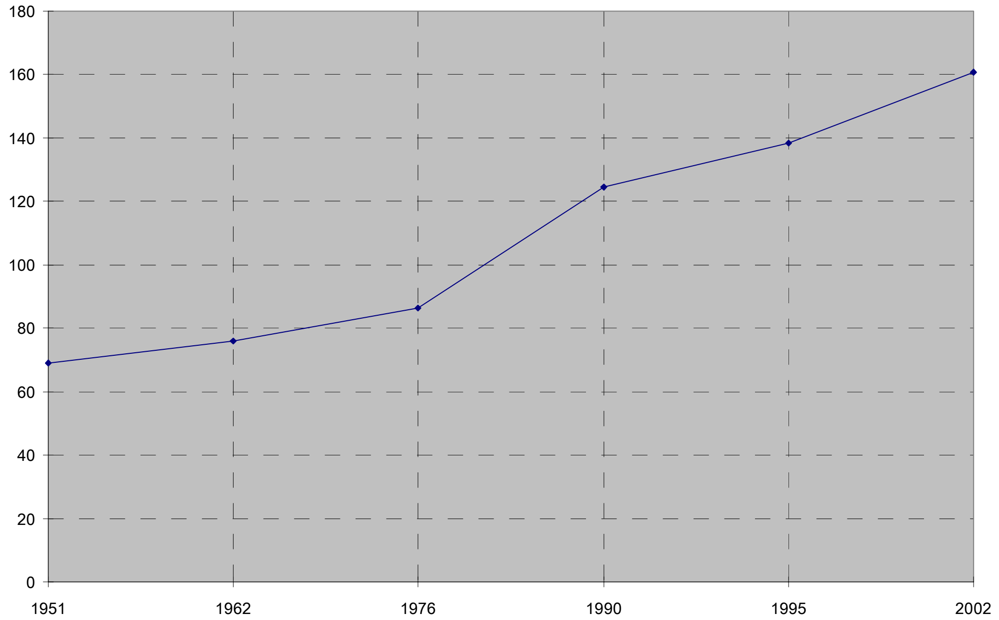

Figure 6: ***Average Standing Stock (1951 – 2002)***

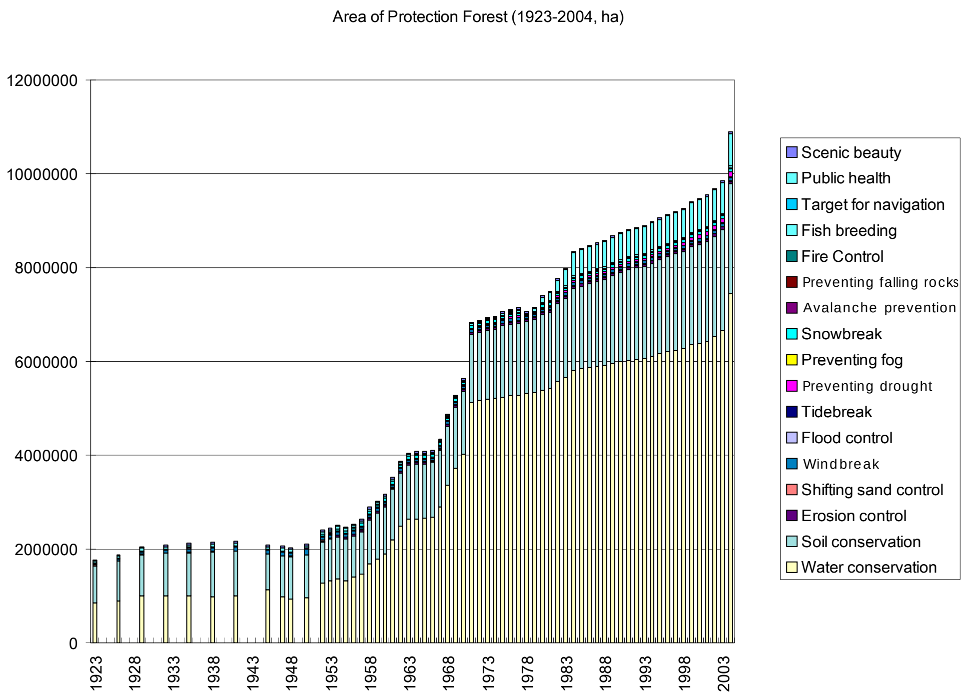

Figure 7: ***Area of Protection Forests***

In the 1980s, the protection forest area was rather stagnant, probably because economic activities were stagnant as well, so that there was little request to designate protection forests, especially for water conservation purposes.

We see changes in the 1990s when protection forests for public health increased. Originally, protection forests for public health were for cleaning up air and for ensuring a less noisy environment. However, around 1990 forests for recreational purposes have also increased similarly to the increase in protection forests for public health provision.

As we have mentioned in the beginning, two thirds of Japan's land area is covered with forests. These forests grow well as the average standing stock per area indicates. However, there are some issues to be addressed.

Firstly, 40% of total Japanese forests are timber plantations. For the plantation forest, delay in thinning becomes one of the focal points in the country's forestry policy. These forests were planted in densities of 2000 to 3000 seedlings per hectare with the aim to apply intermediate thinning until reaching maturity. In the 1950s and 1960s, thinned trees were still harvested with profit. The stronger the Japanese Yen became, the more foreign timber could be imported cheaply. Combined with an increase in the Japanese wage rates forestry operations both thinning and final harvesting at ages of 40 to 50 became unprofitable.

Today, global warming becomes one of the most important issues. The utilization of forests should not be dealt with only from a monetary point of view. Forest, and especially plantation forest, sequestrates carbon from the air. Not only harvesting plantation forests, but also thinning in plantation forest is important for combating global warming. Out of today's 40% of plantation forests in the country, some require to be transformed to natural forest, particularly when we consider biodiversity conservation.

The rest or 60% of Japanese forest is natural forest in need of some kind of management. "Natural forest" is defined as "not planted forest" and managed on the principle of self-regulation like virgin forests. In the past, most of the natural forests were utilized for firewood and charcoal and regenerated naturally after harvesting operations. Because of the shift in demand for firewood and charcoal, wood production became negligible in the 1960s. With the decline in harvesting the natural forests became older with less and less area under natural regeneration. This development favored the spread of the pine wilt disease and the invasion of bamboo species into the original natural forest. Today, Japan is facing new challenges in establishing a proper relationship between human society and these older natural forests.

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Managed Natural Forest of the Tokyo University Forest in Hokkaido

Forest Rehabilitation in Mongolia

by

J. Tsogtbaatar[1]

1. General Information

1.1 Location and Area

Mongolia's geographic location as a landlocked Central Asian country is characterized by a harsh continental climate with long and cold winters, low precipitation and large annual seasonal fluctuations in air temperature.

Mongolia is situated in Central Asia, between 41° 35' and 52° 09' north latitudes and 87° 44' and 119°56' east longitudes. It occupies a unique geographic location. Its territory comprises 156.65 million hectares and has frontiers with Russia and China. Mongolia is a mountainous country with an average altitude of 1580 m a.s.l. 82.2% of the country lies above 1000 m and the highest point, the Huiten peak, is 4,374 m above a.s.l. Based on topographical features, the country can be divided into: (i) the mountains located in the north and the west; (ii) the intermountain basins where the major farming regions area located; (iii) the plateau and desert belt located in eastern and southern Mongolia; and (iv) the rivers and lakes. In addition, four geographic regions are commonly referred to: the Altai mountain on the western border, the Khangai-khentei mountain in North-Central Mongolia, the East Mongolian region coinciding with the *steppe* region, and the Gobi region in the south and southeast.

The highest and the longest spine of mountains is situated in the most western part of the country, the Altai, which extends for about 1500 km. Most of the southern part of the country is a vast rolling oasis-dotted plain, forming the northern fringe of the Gobi, which is predominantly stony with sands covering only 3% of the terrain. The Gobi occupies about one-third of Mongolia's territory. The great desert of Central Asia joins in from the south.

The country has a large number of rivers and streams, some of which are seasonal, with a total length of about 67,000 kilometers. The great divide, separating waters that flow into the Arctic and the Pacific oceans and into the interior basins of Central Asia runs along the crests of the Hentey, Hangay and the Altai mountains. Mongolia's greatest, but third longest river, the Selenge drains northward towards Lake Baikal in Russia. The territory of Mongolia is thus in a confluence zone of three very important watersheds.

There are some 4,000 lakes of more than 100 hectares scattered throughout Mongolia. Uvs Nuur, the largest lake has an area of 335,000 hectares. Mongolia also has a large resource of underground water with about 7,000 hot springs of which many are of medicinal value.

Situated far from the moderating influences of the world's oceans, Mongolia experiences a markedly continental climate with cold winters and warm summers. The high altitude and the relatively high latitude exacerbate the semi-arid continental climate, resulting in long winters. The mean temperature is below freezing point during about seven months in a year.

Mountain areas are always cold and windy. Winter temperatures can drop to -30° C in Ulaanbaatar; extremely low temperatures of -53^{0}C have been recorded in the northern part of the country. The ground freezes down to 3 m and the number of cold days amounts to about 220 a year. The summer is pleasant without being hot. The frost-free growing season averages 115 to 120 days per year.

In the Gobi, summer temperature can hit about 40° C. The dry mountain air and the tempering of heat by summer rainfall, nevertheless, ameliorate the more extreme conditions. Average winter temperature is about 4° C, but winter winds can cause mercury to plummet as low as -30° C. Temperature varies not

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only between seasons, but also within a day. Temperature variation of as much as 30^{0}C may occur in a single day. In the extremely cold weather, Mongolians have to spend a high cost, simply to stay warm. Humidity level is very low in Mongolia. A special feature of the climate of Mongolia is the number of clear sunny days, averaging between 220 and 260 in a year.

Precipitation is unequally distributed both temporally and geographically. Annual precipitation varies from 600 mm in the northern mountain range to below 100 mm in desert regions. There is a short rainy season from mid July to September. The average annual rainfall in the northern forest zone is about 300 mm per year and about 180 mm in Ulaanbaatar.

A major dimension of the natural environment of any country is the ecological equilibrium involving soil, water, flora and fauna. In many cases, the equilibrium has been disturbed in Mongolia. In spite of it, Mongolia's natural environment is probably in comparatively better shape, compared to many other countries. The country's small population and nomadic subsistence economy has been the safety factor in the past, but things are changing fast.

Of the (approximately) 200 global eco-regions two important ones fall in Mongolia: (i) Altai Sayan mountain forests and (ii) Daurian *steppe*. Bio-geographically the country is divided into six regions: high mountains, taiga forest, mountain forest *steppe* (interspersed forests and grasslands), *steppe*, desert *steppe* (arid lands with only sparse vegetation) and Gobi. [The National Plan of Action to Combat Desertification in Mongolia divides the country into 5 agro-ecological zones: Hangai-Houvsgol, Selenge-Onon, Altai, *Steppe* and Gobi].

The borders of Mongolia contain the transition zone between the great *taiga* forests to the north, the Gobi desert to the south, the Altai Mountains to the west, and the central Asian steppe to the east. For this reason, Mongolia is important in terms of ecosystem and species conservation. Its harsh climate, characterised by extreme temperature fluctuations, low precipitation and severe winters produces fragile ecosystems which are easily degraded by human activity; and are slow to recover once damaged. Some 80% of the country is prone to desertification. Economic development, therefore, should be carefully directed to avoid undue adverse effects on the natural environment. As is the case of many rapidly industrialising countries, environmental conservation received little consideration in the country's industrialisation and urbanisation process. The new Mongolia faces a depleted resources base and severe degradation of the environment.

1.2 Land Classification by Vegetation Types

The vegetation of Mongolia comprises plants of two large floristic regions - the Siberian Baikal *taiga* in the north and the central Asia *steppe* desert in the south. The main forest region located in the northern part of the country along the Russian border forms a transition zone between the Siberian taiga forest and the central Asian steppe zones. The basic vegetation form in the *taiga* belt is larch and cedar (Siberian pine).

Climatic and soil conditions are reflected in the vegetation patterns. Latitudinal and altitudinal belts of vegetation, often changing rapidly over a few miles, are probably the most obvious feature of the local Mongolian landscape. There are four basic zones running from north to south: the forest-*steppe* zone of the mountains; the mountain *steppe* zone; and in the south and extreme south, respectively, the semi-desert and desert zones. In addition, the mountain areas are characterized by two successive altitudinal belts: the mountain taiga and the alpine zones. The *steppes* predominate, covering about three quarters of the national territory.

The mountain forest *steppe* zone, with two superimposed altitudinal belts covers about 30% of the country and exhibits the richest diversity of plant and animal life. Forests grow thickest on the northern shady slopes, the most widespread tree being the Siberian larch, followed by the cedar, with a varying admixture of spruce, pine, and fir (Figure 1).

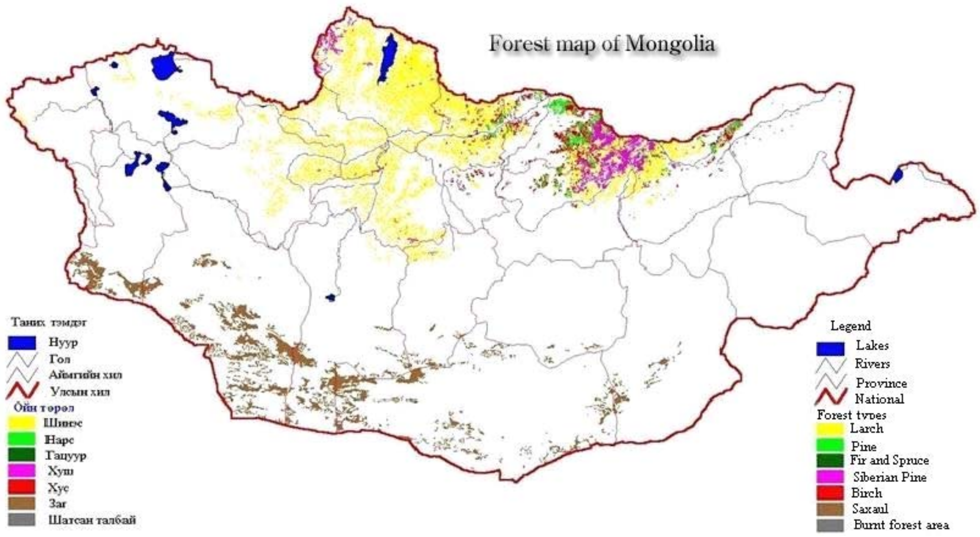

Figure 1. ***Forest Map of Mongolia***

Deciduous trees include species such as birch, aspen, and poplar. Depending on the altitude, the mountain *taiga* can be divided into 4 belts: *subgoltcy*, *taiga*, *sub-taiga* and *pseudo taiga*. The lowest boundary lies at an elevation of about 650 m and the upper boundary is at about 2600 m.

Sub-alpine: Often covers the upper most line of forest. Regeneration is slow with cold-resistant plants and those that grow on rocks as well as moss and lichen. It has significant importance as source of spring water and in protecting soil. The Mongol Altai *subgoltcy* forest was heavily logged and there are many spots that turned into *steppe* ecosystem due to insufficient forest rehabilitation.

Taiga belt: *Taiga w*ith permafrost soils underneath is found in Hentey, Eastern Khuvsgul, South Eastern and Western Khangai forest vegetation region. Natural rehabilitation is adequate. However, when impacted by forest fire and logging, coniferous species are often replaced by birch trees. Although birch and larch trees are dominant, cold-resistant *taig*a elements such as Siberian pine and fir are common.

Sub-taiga belt: its specific vegetation occurs in Mongolia only, especially in the Khangai and Altai ranges. The main species is larch. The forest not impacted by human activities maintains itself through natural regeneration processes, but is replaced by the *steppe* eco-system when clear-cut. Rehabilitation should be provided through selective cutting and forest fire prevention.

Pseudo-taiga is the most widely spread forest type in Mongolia and the main resource for logging. In addition, it is most heavily impacted by human activities and thus prone to forest fire because of its location at the border of the *steppe* zone. This type of forest consists of larch, pine and birch and is also rich with decorative and medicinal plants. Although its natural regeneration is good, coniferous trees are replaced by deciduous trees such as birch and poplar after forest fire and/or logging. In some cases, the forest is replaced with the *steppe* eco-system. Rehabilitation and reforestation activities are to be focused on this belt.

On the highest mountain slopes, the damp, dark, coniferous forest of the *taiga* gives way to the thin grasses and occasional flowers of the alpine zone, merging into the bare rocks and rugged glaciers of the summit zone. *Steppe* vegetation is found in the inter-mountain basins, the wide river valleys, and the sunny southern flanks of the mountains. These huge expanses of pastureland are covered with feather grass, couch grass, wormwood, and many fodder plant species. Belts of willow can often be found along river banks. In summer, the *steppes* are carpeted with a magnificent layer of bright violet, blue, red, and yellow flowers.

Semi-deserts are found in the Great Lakes inter-mountain depression and, in general, in the Gobi desert, giving way to true desert conditions near the southern border. Vegetation there is scarce but still enough to feed camels, goats, and sheep. Tracts of saxaul and groves of elm, poplars and Tamarix cluster around springs or other underground water sources. Only in the far south there is a narrow belt of the Gobi. This is a typical rock-floored desert with gravel cover. Only the far eastern part has small areas of sandy desert.

Today, it is estimated that Mongolia's forest land covers less than 12.4 million ha of intact forests, with a further 3.6 million ha of degraded forest and 1.8 million ha of non-forest land. The forested regions within this estate can be broadly divided into predominantly coniferous forests of the north and shrub forests of southern deserts and desert steppe.

In broad terms of vegetation classes, Mongolia can be divided into: grassland and shrubs (about 53%); forests (about 12%) and desert vegetation (about 34%). About one percent is used for human settlement and crop cultivation. Grazing takes place in all these classes. Vegetation types of natural grazing land, which cover about 83% of Mongolian territory, are distributed as shown in Table 1.

Table 1: ***Distribution of Natural Grazing/Pasture Land by Vegetation Types***

Vegetation Type	**Percentage**
High mountain belt	5.3
Mountain forest *steppe* belt	27.1
Steppe zone	22.8
Desert *steppe* zone	19.5
Desert zone	19.4
Inter zonal vegetation	5.9
	100.0

(Source : GOM/MNE, 1998)

The actual area used for pasture, however, covers only about 79.0% plus 0.9% for hay-making.
Even though the extent of forests in Mongolia is relatively limited, it is distinctive and somewhat heterogeneous, because of the country's vast territory and geography, and it is of enormous importance in supporting the environmental stability and security of the country. The global externalities of the forests of Mongolia are considerable.

1.3 Extent of Forests

The forest cover of Mongolia extends over an area of 17.51 million hectare or about 11.2% of the country's territory. Of this, the area actually under closed forest cover is about 12.71 million ha, representing about 8.1% of the country's total area.

It has been estimated that the average growing stock of wood per ha in the coniferous and deciduous forests is about 103 cubic meter. Main tree species found are : *Larix siberica, Pinus silvestris, Pinus sibica, Picea obovata, Abies siberica, Betula platyphylla, Populus tremula, Populus diversifolia*, and *Salix* spp.

According to the Mongolian forest law, forests in the country have been divided into three categories by their significance for management and utilisation:

The *Strict Forest Zone* (meaning strictly protected zone) or special forest zone covers an area of 8.44 million ha and includes the strictly protected sub-alpine forests and those parts of the protected highland areas which have already been included in the network of the established Protected Areas, and also PAs in other areas like the *steppe* and desert. By and large, these densely forested zones have been considered as part of Mongolia's emergency strategy. These forests cover up to 48.2% of the country's total forested area.

The *Protected Forest Zone* covers an area of 7.88 million ha and includes natural forests and woody plant reserves in the green zones, forests in the buffer zones, all saxaul forests, forests in oases and on mountain slopes steeper than 30 degrees. Forests in this category cover 45% of the total forested area.

The *Utilization Forest Zone or industrial forest zone* covers an area of 1.19 million ha and includes all other forests, excluding those mentioned in other categories. This zone consists of forests where selective timber cutting and logging are allowed. These forests make up about 6.8% of Mongolia's forests.

In recent years, Mongolia has expanded the area under the protected area system, which, in 2000, was reported to be 20.5 million ha, about 13.1% of the territory of the country. However, for lack of funds, facilities, manpower and infrastructure the protected area system is not adequately maintained and managed. The government has plans to increase the protected area to cover up to 30% of the territory; but an aspect for consideration is their proper management and how to generate funds on a self-sustaining basis.

Reports indicate that between 1974 and 2000 forest cover over an area of 1.6 million ha has been lost. Loss of forest cover aggravates wind and water erosion, increases evaporation and lessens snow retentions; leading to desertification.

1.4 Deforestation

Deforestation and forest degradation have local, national and regional concern, due to their economic and ecological costs. The important causes of deforestation and forest degradation are fire, overgrazing, mining activity, improper commercial logging, illegal collection of wood for construction and for use as fuel, hay-making in forest *steppes*, complacency in enforcement of forest rules and regulations, and damage by pests and diseases. Between 1990 and 2000 some 8.13 million cum of timber were removed from an area of over 65,000 ha in commercial logging, 7.52 million ha of forest were burned by fire, 1.28 million ha of forest were damaged by harmful insects, in addition to damages inflicted by grazing and other anthropogenic factors.

The impact of the political and economic transition has been somewhat more severe on forestry compared to other sectors; and recovery is slower or not yet evident in most cases. Quality of forest management continues to be inadequate, indicated by poor natural regeneration and ecological retrogression. Recorded wood production is reported to have fallen, due to the reduction in the area of designated utilization forests. However, since harvesting is confined to limited and easily accessible areas and hardly any control is exercised on the operations, wasteful over-harvesting takes place. Illegal/unaccounted removals are also common.

1.5 Changes in the Political Landscape

In the context of achieving the goal of creating a democratic society in Mongolia, a lot has been done during the last fifteen to seventeen years in the areas of political, economic, social, administrative and management structure and organization.

Mongolia is a unitary state, administratively divided into 21 aimags (provinces) with the capital city Ulaanbaatar. Aimags are subdivided into 336 soums, each soum is divided into 4-6 baghs which is the basic administrative unit depending on population and territorial area. It is a very important aspect to develop and establish precise tasks and responsibilities of administrative and territorial units in the country, where about half of the population lives in urban areas and the remaining part has a totally seasonal nomadic life.

The New Constitution of Mongolia adopted by the State Great Hural (Parliament) in January 1992 has determined the Government's role in multiparty democracy. According to the New Constitution, Mongolia is a unitary state with the territory divided only into administrative units. The power is shared between the President, the Parliament, the Prime-Minister's Cabinet and the Supreme Court. The President and Parliament members are elected directly by the people at two different elections.

Only the Parliament has legislative power. It determines the basis of the domestic and foreign policy, approves and makes changes in laws, determines and announces Presidential and Parliamentary elections, appoints and dismisses government members, defines the state financial, credit, monetary and tax policies as well as the basic guidelines for the socio-economic development of the country. It also approves and dissolves the territorial and administrative units and regulates the system and the organizational structure of these units.

Article 59, Chapter IY of the Constitution of Mongolia states that "The governance of administrative and territorial units of Mongolia is exercised based on the combination of local self-governance with state governance" which is further clarified by the "Law on Administrative and Territorial Units of Mongolia and their Governance". It stipulates the competence and duties of local governance and the principles for its organization and elections.

The political and economic changes occurring in Mongolia are creating an environment for the existence of various types of ownership. Moreover, there is a need to radical change in the principles of economic management compared to the centrally planned period of the past. The changes brought about therefore have some positive results in this regard. The transitional process of the last fifteen years has demonstrated the importance of the development of management skills and tools suitable for the transition period towards market relations and beyond. It also shows the need for strengthening local administrations, building up the capacity of economic entities with various forms of ownership, expanding their production and service, and adapting to market relations and fair competition.

Since 1987 policy changes, from a centrally planned and command system, started to emerge in all aspects of national life **–** with changes taking place through reform of the structure and functions of State institutions and institutional instruments, aimed towards a free market economy. This transition process presented development challenges as well as opportunities.

In 1990, in the context of the transition from a centrally planned system to a market economy, Mongolia initiated far reaching reforms, and moved rapidly to establish the necessary legislative framework, covering legal and business entities, contracts, fair market place, labor, financial matters, property rights and so on. Following widespread dissatisfaction with the single party system, political reforms were made in April 1990 through various amendments to the 1960 constitution allowing, *inter alia*, legal formation of political parties. Parliamentary elections were held in August 1990 and this was followed by adoption of a radically new constitution, embracing democracy and market economy. The new Constitution which took effect on 12th February 1992 changed the name of the country from People's Republic of Mongolia to Mongolia.

The 1992 Constitution of Mongolia includes the following major elements:

- Mongolia is a unitary State and the territory is divided into administrative units.
- The State recognizes all forms of public and private property.
- The land, except that privately owned by citizens, as well as the subsoil with its mineral wealth, forests, water resources and game shall be the property of the State; grazing land will be under public control.
- The citizens of Mongolia shall enjoy, among others: the right to a healthy and safe environment, and be protected against environmental pollution, and ecological imbalance; and the right to fair acquisition, possession and inheritance of movable and immovable property.
- The *Ikh Khural* is the highest organ of state power and the legislative power shall be vested solely therein. Members of the Ikh Khural are chosen in national elections, every four years. Major responsibilities of *Ikh Khural* include ratification of laws and the State budget. *Ikh Khural* is divided into Standing Committees dealing with various matters. The Standing Committee on Rural Policy and Environment is concerned with forestry issues. Head of the State is the President, elected by eligible voters. The Government, the highest executive body of the State is headed by a Prime Minister supported by ministers. Government acts on a cabinet principle. Term of mandate of the Government is 4 years.
- The territory of Mongolia is divided administratively into *aimags* and cities. *Aimags* are divided into *soums* and *soums* into *baghs*. (Cities are divided into *duuregs* and *duuregs* into *horoos*).

- The Governance of administrative and territorial units of Mongolia shall be organised on the basis of a combination of the principles of both self-government and central government. The self-government bodies in *aimags*, cities, *soums*, *duuregs* shall be *khurals* of the representatives of citizens of respective territories; in *baghs* and *horoos,* it will be general meetings of citizens. In between the sessions of the *khurals* and general meetings the presidiums shall assume administrative functions.

- State power shall be exercised in the territories of *aimags*, cities, *soums*, *duuregs*, *baghs* and *horoos* by the Governor of these territories appointed for a term of 4 years. Governors *of aimags* and cities are nominated by the respective *Khurals* and appointed by the Prime Minister. Governors of other territorial units are similarly nominated by the *Khurals* and appointed by the Governors of the immediately higher territorial administration.

- Local self-governing bodies can make independent decisions, in conformity with the Constitution, on matters concerning the economic and social life of their respective territories. Governors have the right to veto the decisions of the respective *Khurals*.

- Authorities of higher instance shall not take decisions on matters coming under the jurisdiction of local self-governing bodies.

The 1992 Constitution is Mongolia's supreme legislative document. Mongolia's Development Policy, which is an umbrella policy influencing other sectoral policies in tune with reform process covers aspects relating to public administration and civil service reform, decentralization and local administrative strengthening, privatization and privatized enterprise restructuring, private sector development, promotion and encouragement of small and medium sized entities, management development and strengthening of institutions. Priority is on: privatization and enterprise restructuring; promotion of small and medium sized enterprises; and decentralization and local administration.

The economic crises of past years have affected the whole society. In particular, many problems needing urgent solution have appeared in both the social and environmental sectors. Until 1991 almost all assets and production were in the state owned sector. But dramatic political changes since that time have brought about a significant private sector, largely as a result of Mongolia's privatization program. Consequently, the public sector has significantly shrunk both with regard to asset value and the number of economic entities. Cabinet resolution #170 (1991) determined a list of enterprises and industries subject to full or majority state ownership, treating them as a means of conducting government policy and reducing the temporary hardships of the transition period. That list includes those industries which were difficult to privatize in the short run, as well as those that are vitally important for exports and fiscal revenues. These included central energy system entities, coal mines, copper plant, telecommunications, railroad, civil air company, water supply and sewage companies and forestry and wood industry companies.

Since small privatization was initiated in October 1991, followed by large scale privatization from February 1992 onwards, a significant share of formerly state owned assets have been transferred to private hands. Overall, the Mongolian Privatization Program has relatively well accomplished its market economy infrastructure building role, by creating a private sector and the supporting macroeconomics stabilization policy.

The post-1990 transition has been implemented by the enactment of literally hundreds of pieces of legislation. The problems of administrative implementation of so many laws in such a short time have been enormous, and as a result, implementation is not keeping up.

1.6 MAP 21 – Mongolian Action Program for the 21st Century

Mongolia's National Council for Sustainable Development (NCSD) established in April 1996 was assigned the lead role to plan, organize, manage and co-ordinate all national activities relating to sustainable development. NCSD undertook the task of preparing the Mongolian Action Program for the 21st Century (MAP 21), to define the national development strategy based on a holistic and participatory approach to planning and to set goals for the nation's development in ways which are environmentally friendly, economically stable, and socially healthy. Work on MAP 21 was undertaken with the support of UNDP.

The MAP 21 document, the result of a long and profound consultation process lasting for about two years, was released at a National Summit on 16 June 1998. MAP 21 is divided into four main parts and 26 Chapters and includes sustainable social development; sustainable economic development; proper use of natural resources and protection of nature and the environment; and means of implementation.

The document has recognized the importance of forests in supporting national development. Chapter 13 of the document deals with the use and conservation of forest resources. The document underlines that the challenge faced by Mongolia's leaders is to develop policies, regulations and management instruments that, while allowing careful use of specially designated areas of the country's precious forest resources for important economic activities and implementation of reforestation and afforestation programs to expand the total forested area in the country, while making it possible at the same time to set aside critical forest areas as protected eco-systems where only non-destructive uses such as species protection, controlled hunting and eco-tourism are to be allowed.

Several areas of action have been identified in the document, such as: educating people about the importance of forest protection; strengthening management and organization; dealing with the financial and economic factors that lead to irresponsible forest exploitation; developing better skills and human resources for forest management; achieving greater scientific understanding and conducting forest related research; establish and improve measures for protection of bio-diversity and wildlife conservation; contribution towards prevention and combating of desertification; creating information and promotion systems; evaluate forest raw material sources; improved use of forest resources; establishing afforestation programs; creating conditions for development of forest tourism; strengthen planning, evaluation and control.

MAP 21 followed a participatory approach and it is becoming firmly established in the minds of local authorities. MAP 21 also foresees a phased development approach, for strengthening capabilities at local levels including operation systems and procedures, staffing, training requirements, equipment and facilities, budget plans and so on.

Since MAP 21 provides only an overall approach and an umbrella for coordinated socio-economic development of Mongolia, it is essential that specific national action programs are prepared for the major sectors such as forestry. It is the expectation that specific action programs pertaining to individual sectors, sub-sectors and subject areas of importance will follow. The Water and Sewage Program for the 21st Century (WASP 21'), and Action Program of Science and Technology are examples of such initiatives.

Complementary to MAP 21 (and also independent of it) a number of national plans had been prepared in the field of environment, prior to the release of MAP 21:

- National Environmental Action Plan (approved by Government in 1995)
- National Action Program on Protection of Biodiversity (approved by Government in July 1996)
- National Plan of Action to Combat Desertification (approved by Government in July 1996)
- National Program on Public Environmental Education (approved by Government in December 1997)
- National Action Plan for Special Protected Areas (approved by Government in May 1998).

All or most of these contain references to forest, mostly extolling its virtues and suggesting the need for its proper utilization, rehabilitation and management. Unfortunately, there is great gap between what has been planned and what is actually implemented, due to non-availability of funds. In fact, all of the above remains unimplemented.

As a follow-up to MAP 21, the Ministry of Nature and Environment (MNE) had also indicated the need to formulate the following specific plans/program for early implementation.

- National Forest Program
- Action Plan for National Disaster Management

- Water Resources Action Program
- Solid Waste Management Action Program
- Clean Air Action Program
- Action Program for Wildlife Resource Protection
- Eco-tourism Development Plan
- Environmental plans for local *aimag*s

The capabilities to attend to the massive planning task at MNE are weak, due to lack of a rational definition of priorities and related responsibilities, lack of adequate human resources and skills, lack of information, and other institutional constraints. Pertaining specifically to forestry, it is understood that two specific plan documents were developed by the erstwhile Bureau of Forestry and Wildlife of the MNE, some time ago.

- Forest Resource Protection Program (up to 2005),
- Reforestation Program (up to 2010), *and*
- Green Wall Program (up to 2030).

2. Status of Forest Rehabilitation

2.1 Forest Degradation

Forest Degradation results from misuse and/or mismanagement of the resource. While not as conspicuous as deforestation, its impact on the environment can be very serious.

According to a survey of human impact on ecosystems in Mongolia during the last 100 years, it is seen that some 40% of all forests in Mongolia have been affected to some degree; 684,000 ha have not regenerated after fire damage and 250,000 ha after clear-cutting; 1,737,000 ha of coniferous forests have been replaced by birch and poplar stands, 159,000 ha by *steppe* and sand/stones, and 1,230,000 ha by low quality coniferous forests. Cold-resistant *taiga* forest has been shrinking. 16% of the forest ecosystem has been replaced by non-forest ecosystems (Tsedendash, 1998).

Some of the factors and impacts linked to deforestation and forest degradation such as forest fires, grazing, erosion of biodiversity and desertification are relevant in this connection. Scientists indicate that naturally (due to natural causes) forest fire would occur in the taiga forests at an interval of about 150 years, whereas in the Mongolian forests the frequency cycle has been reduced to 4 to 5 years due to anthropogenic factors.

Forest fires, by far, have the most serious impact on the forests of Mongolia. Forest fires are mostly of incendiary nature, caused by herders and collectors of antlers. Low intensity forest fires that cover lower layers of the forest (ground fire) lightly burn the tree stems and cause less damage, whereas the fires that cover upper layer of the forest (crown fire) burn branches and leaves of the trees which essentially stops the growth. More serious fires will completely burn and destroy the forest vegetation. In some cases, fire damaged areas recuperate through revival of the affected plants or through natural regeneration.

Even light forest fires can attract pests and diseases, and plants weakened by fire become easily susceptible. Forest fires result often in a replacement of coniferous forest with birch or *steppe* vegetation. Berry bushes and medicinal plants are lost, and wildlife is adversely affected. Fire, coupled with grazing, leads to increased soil erosion.

Historically a number of massive forest fires took place, for instance, in periods of 1968-1969, 1977-1978, 1985-1987, 1990-1991, and 1996-1999.

The forest area damaged by fire in 1980 was 107,200 ha (compared with an area of 115000 ha damaged by insects). In 1990, the corresponding figures were 649,800 ha and 33,100 ha; in 1994 they were 120,000 ha and 135, 000 ha respectively (Adyasuren, 1998). Since then, the area of fire damage has increased. In 1996, the total area affected by fire was 10.20 million ha, of which the forest area involved was 2.36 million ha, the rest being pasture and *steppe*. 25 people were killed and 700 rendered homeless in the 1996 fire. It burned 307 million cubic meter of forest growing stock of which some 22 million cubic meters were totally lost. In 1997, fires burned 12.4 million ha of which the extent of forest area affected was 2.7 million ha; 600,000 livestock and an unknown number of wildlife were destroyed. The damage to the Mongolian economy was estimated at a staggering US $ 1.9 billion (Tsedendash, 1998). Heavy investments will be required for rehabilitating the fire damaged forest. However, due to resource constraints, action has been delayed.

The Forest Law of Mongolia (1995) stipulates that the Governors of local governments shall design and implement programs for forest protection and allocate required financial resources. These provisions are, however, not followed in practice, and the deleterious effects of it are evident. No system exists for fire damage rating, fire prediction, observation and forest fire warning; nor is there a system of fire lines/ fire breaks for fire prevention and fire fighting. No trained fire-fighting squad exists. The few (some 15) fire observation towers in the country are either inoperative or ineffective. Adequate funds are also not available. In fire disaster situations, State Emergency Commission and Civil Defense Force provide some assistance. A program to develop a system of fire prevention, early fire detection, rapid response and effective fire fighting is a high priority. A pilot project supported by the German Agency for Technical Cooperation (GTZ) on Integrated Fire Management in the Khan-Hentey Protected Areas, incorporating the herders living in the buffer zone, was recently implemented. A FAO-TCP project (MO-0068) on strengthening capacity for disaster response and forest fire prevention is currently under implementation.

2.2 Forest Utilization

In the 1950s, the Government of Mongolia, following the Soviet model, had established 12 forestry state enterprises in several of the northern-central *aimags* including settlements for workers ('forestry villages'). In order to intensify forest management mechanical harvesting operations and electronic sawmilling were introduced. These sawmills needed large timber volumes and thus the forests were clear-cut extracting up to 2 million cubic meters of timber annually.

In terms of age structure, Mongolia's forest is mostly old growth forest that is distributed in the taiga belt with high soil erosion risks or on steep mountain slopes, which are inaccessible with the current harvesting technologies. Forest exploitation in the past has exhausted the timber resources in more accessible areas given the capacity of their equipment and transportation systems. Between 1940 and 2000, in total 43.8 million cubic meters round wood were harvested from more than 320,000 ha of forests.

Comprising more than 50 pieces of legislative acts (i.e. laws, resolutions, orders, rules etc.), Mongolia's package of forestry-related laws and regulations are perhaps the most detailed and complete of all its environmental laws. Most of this legislation deals with timber harvest and reforestation.

According to the Mongolian Law on Forest (1995), the State has the power to grant possession of Forest Reserves to the municipalities of Capital City, Aimag and Soum. Their citizen representatives have the power to grant the use of forests and non-timber products to citizens, economic entities and organizations as well as the use of forests for certain periods, fees, and conditions based on the contracts or licenses. According to this article of the law, the forest administration is fully decentralized and the *soum* governor is empowered to grant licenses and concessions, respectively to individuals or economic entities, and collect the respective fees. Control is also under local authority. But in terms of determination of allowable harvest volumes, it is a very top-down process. First, the MNE determines the allowable harvest for each Aimag and Capital City on an annual basis. Then, their citizens' representative decides on the permissible cut within the limit determined by the MNE. Finally, the Soum Hural decides on the permissible cut within their territories based on the Aimag Hural decision.

Bids to timber harvest for commercial purpose by individual persons and entities are to be submitted to the Soum and capital city governors. These governors make decisions within permitted limits by Hural and under consideration of

1) the economic efficiency of the activity,

2) harvesting technique, processing technology and level of use

3) available funding for protection and regeneration measures, *and*

4) evaluation by certified professional organizations.

On the production front, the annual volume of logging which was about 2.2 million cubic meters in the mid-1980s fell to about 0.5 million cubic meters in 2000. This decline in harvest level is partly due to the influences of institutional and policy changes involving privatization of production enterprises and decentralization of decision powers. But partly it is also due to the supply constraint caused by a reduction in the area of designated utilization forests from about 5.8 million ha in 1985 to 2.4 million ha in 1990 and further to 1.19 million ha in 1996 (i.e. because of reclassification of some of the utilization forests as protected areas). Also, the Forest Law of Mongolia prohibited clear felling of natural forests and prescribed selective cutting, in 1995.

The harvesting practices are also wasteful and inefficient. The wastage level which used to be about 25 to 30% in the clear-felling system has recently increased to about 60% under the selection cutting system.

The MNE estimates, that the area of exploitable forest is somewhere between 5 and 8 million hectares. During the 1980s, the former Soviet forestry specialists recommended an Annual Allowable Cut (AAC) of 2.5 million m^3. Foresters estimate this at about half the natural annual growth rate of the forests. However, as mentioned above much of these timber resources are located in protected or otherwise inaccessible areas. This has resulted in a concentration of cutting in the more accessible locations while the rest of the forests are left relatively untouched. Again, most of the logging companies operate along the railway in the northern part of Mongolia, especially in Selenge *Aimag,* which produces 60% of the timber volume.

The number of official wood industry related companies and organizations have been reduced significantly. At the end of 1989, each *Aimag* had an average of 18 forestry units (324 throughout the country), 16 logging organizations (288), 6 wood processing plants (108) and 5 carpentry stations (90). By 1996, this profusion of wood related organizations had shrunk to 49 sawmills and furniture factories.

The official statistics on timber harvests over the past 15 years show a correspondingly dramatic decrease in harvest levels from a high of 2.24 million m^3 in 1995 to just 464.4 thousand m^3 in 1999 (Figure 2).

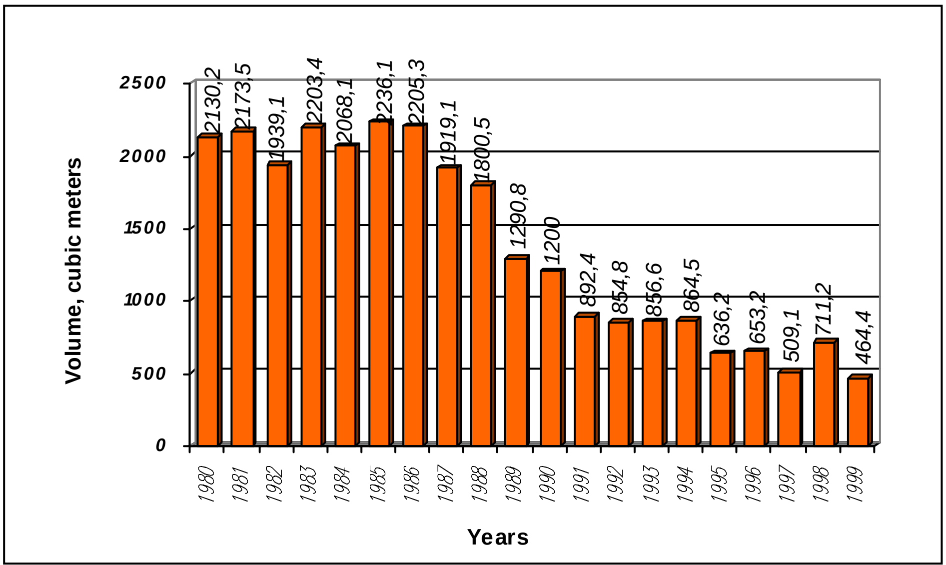

Figure 2: ***Timber Production, m^3 (Source: National Statistic Bulletin, 1990-2000)***

2.3 Forest Fires

Wild fires, by far, have the most serious impact on the forests of Mongolia. Forest fires are mostly of incendiary nature, caused by herders and collectors of non-timber forest products. In Mongolia, fire is a major factor which determines spatial and temporal dynamics of forest ecosystems. It also drives the trend of forest formation, varying with altitude. Out of the total of 18 million ha of forest land, 4 million ha are disturbed to different levels either by fire (95%) or by logging (5%). Logged areas have increased drastically for the past 20-25 years. 600,000 ha of cuts have not yet recovered (Gunin et al. 1992).

2.4 Uncontrolled Grazing and Lack of Pasture Management

General health and condition of pasture land in Mongolia is poor with unregulated grazing of some 34 million heads of livestock, such that the grass does not get a chance to re-grow. Some 35 to 40% of the livestock population (about 12 million) is allowed to graze in and near forest areas, trampling young trees and saplings, inflicting heavy environmental toll on the land. Grazing occurs also in protected areas. Grazing was observed even in the forest arboretum in Ulaanbaatar.

To save forests from grazing damage, action needs to go beyond the forest boundary, by promoting good pasture land management **–** improvement of pastures, controlled and rotational grazing, fodder development and other science-based measures.

2.5 Loss of Biodiversity

Negative impacts of inadequate forest protection are serious, often irreversible. Deforestation and forest degradation, often, lead to serious reduction in biodiversity levels. 229 species of Mongolia's flora and fauna are endangered and some are at the brink of extinction (GOM/MNE/UNDP/GEF, 1998). The impact of biodiversity loss on the future well-being of human society, particularly on its quest for better health and food security is to be specially stressed here.

2.6 Desertification

Loss of forests, coupled with overgrazing and inappropriate land use practices, leads to desertification and formation of barren, eroding wastelands. During the last 40 years the desert areas of Mongolia have increased by some 38,000 ha and deserts now make up some 41% of the total land area. It has been estimated that the size of usable pastureland has decreased by 6.9 million ha during the last 30 years due to desertification; and 30% of the total pasture area in Mongolia has degraded due to misuse. The area covered by sand has increased by 8.7% (38,000 ha). The size of degraded land is reported to have reached 121.7 million ha (GOM/MNE, 2004).

2.7 Forest Rehabilitation

A major issue related to forest management in Mongolia is reforestation, due to the difficult site conditions. Considering the specific habitat factors existing in Mongolia, sufficient natural regeneration of desired species such as pine and larch cannot often be achieved after logging operations and/or fire incidences. The share of non-coniferous species like birch and aspen increases and some areas may turn into grassland. Under such a situation, artificial planting or sowing with desired species is necessary, to supplement natural regeneration establishment.

Reforestation activities in Mongolia commenced in 1971, some 48 years after the first sawmill was established and commercial timber extraction started. The total area planted in 1971 was only 67 ha and the rate of planting has increased considerably since then. Area planted in 2000 was 9,030 ha. Main species planted are pine (*Pinus silvestris*), larch (*Larix siberica*), poplars (*Populus* spp) and elm (*Ulmus macrocarpa and U.pumila*). Total plantation area recorded by the end of 2006 is 117,943 ha.

The quality of plantations is generally poor and the survival rate of seedlings is reported to be between 30 - 60%, but seldom reaching 50%. The main reasons for the poor standard of the plantations are as follows:

- Lack of compatibility between site and species;
- Poor site preparation;
- Poor quality of planting stock (resulting from poor seeds and nursery technique); inappropriate plantation establishment practices;
- Lack of post establishment maintenance;

- Inadequate measures of controlling fire, pests and diseases;
- Damages caused by grazing; lack of infrastructure; *and*
- The influence of a harsh climate and budgetary constraints.

Expenditure on plantations is minimal and absolutely inadequate to raise successful plantations. For example, the budget allocation for 1997, to raise 5001 ha of plantations (plus maintenance of previous year's plantations) was Tg. 196 million, or about Tg. 39,000 (which, at the prevailing rate of exchange at that time was equal to about US$ 50) per ha.

A major issue relating to forest management in Mongolia is afforestation (another important issue being fire protection), due to the difficult site conditions. In many situations forest plantations are becoming an intensive land management activity and an economic investment. Forest plantations can also serve for site rehabilitation and conservation purposes.

For about 30 years, the Mongolian Government has had a program of tree replanting and plantation establishment. The area successfully replanted represents only 5-7 % of the total forest lost, mostly due to low survival rates of the seedlings. At present, 150,000 ha of forest needs to be restored. However, only 5,000 ha are being restored annually.

Table 2: ***Trend of Forest Plantation Development in Mongolia***

Years	Area Planted, ha
1971-1980	3,086
1981-1990	30,381
1991-2000	50,576
2000-2006	33,900
Total	117,943.0

Source: MNE, 2005

The area planted over a period of some 30 years is very small compared to the deforestation which has taken place (1.6 million ha) during the last 25 years, and the degradation level of the remaining accessible forests. Even if only the area harvested during the period is considered, the reforestation rate is still low. MNE assumes that annual planting will increase to 24,000 ha by the year 2010. Considering that the rotation age of the coniferous plantations, under the present level of technology is about 120 years, it will be a long time before they start contributing to the wood supply.

Efforts to plant trees in the desert ecosystem have been small so far due to technological, funding and climate related problems.

The current regeneration method consists of piling-up and burning the logging waste, manual site preparation and planting of bare-root seedlings. Mechanical site preparation is adopted in some cases. Nursery-raised 2-3 year old seedlings of 20 to 30 cm size (according to the standard) are planted at different spacing, varying from 3 m x 1m to 3 m x 3 m, mostly in 25 cm deep ploughed lines.

Numerous examples of past and ongoing forest rehabilitation initiatives exist in various locations of Mongolia. A wide range of stakeholders such as government agencies, universities, private companies, and local communities are involved in these activities. The selected sites of tree plantation are briefly described based on following aspects:

- Objective of the planting activity
- Success and performance of planting activity
- Factors influenced on success/failure of plantation
- Lessons learned

Site 1. *Reforestation Activity in Tujjin Nars.*
650 ha of degraded forestland in the Tujiin nars area of Selenge Aimag were replanted with *Pinus sylvestris*. This activity was carried out in cooperation with the North East Asia Forest Forum (NEAFF).

Objective of the planting activity
To conduct reforestation activity after fire and clear cutting in former degraded forestland. Main focus is on protection and commercial plantation.

Success and performance of planting activity
In terms of growth performance the project was successful. Survival rate of 70-80% is high, compared with other regions of the country. The degraded forestland was recovered by *Pinus sylvestris* in both private land and Government plantations. NEAFF assisted with training and skill development.

Factors influencing success/failure of plantation
The major success of this activity originated from interest and commitment from Government and local organizations. Experience and local capacity in tree planting influenced the performance of the plantation.

Lessons learned
During the establishment of plantation there were conflicts with livestock grazing in the surrounding areas. There was major concern regarding selection of the plantation period in spring time depending on the extent and timing of rains.

Site 2. *Reforestation Activity in Dukh Nars Area.*
600 ha of degraded forestland in the Dukh Nars area of Bulgan Aimag were replanted with *Pinus sylvestris*. This activity was supported by Hyogo Environmental Advancement Association.

Objective of the planting activity
To conduct reforestation activity after fire and clear cutting in former degraded forestland. The main focus is on protection and commercial plantation.

Success and performance of planting activity
In terms of growth performance the project was successful and achieved a survival rate of about 70% which was high compared to other regions of the country. Before the start of the planting activities a preliminary study on the feasibility of plantation work was undertaken followed by continued monitoring work.

Factors influencing success/failure of plantation
The major success of this activity was based on active participation of the local community. Experience and skill of local people in tree planting significantly enhanced the performance of the planting work.

Lessons learned
Site preparation techniques were tested. Major concern for the success of the tree planting activity was related to fire wood collection and protection from fire dangers after the planting.

Site 3. ***Afforestation Activity in Dalanzadgad of South Gobi.***
Tamarix and Ulmus were planted to rehabilitate an area of about 80 ha of degraded forestland in the desert area of South Gobi Aimag. This activity was supported by the North East Asia Forest Forum.

Objective of the planting activity
To create windbreaks and prevent yellow sand storms which negatively affect surrounding areas of Dalanzadgad city.

Success and performance of planting activity
In terms of survival rate the project was successful. This afforestation activity was associated with nursery development in order to provide quality seedlings of native trees.

Factors influencing success/failure of plantation
The main success of this activity was based on local people's participation and involvement of local experts.

Lessons learned
During the establishment of the plantation, problems related to shortage of water occurred because of low-yielding water wells. Water saving techniques and efficient use for irrigation are important aspects for the future.

Site 4. ***Afforestation in Juulchin Gobi and Bulgan Site.***
This project established wind break forests in an area of about 100 ha in the desert region of South Gobi Province. Support was provided by the Rotary International Foundation and the Korean Rotary Clubs.

Objective of the planting activity
To establish wind break forests for the prevention of yellow sand storms. For the wind break establishment native tree species from the Gobi region such as Ulmus pumila, Tamairix and other tree species were used. Emphasis was also given to create new jobs for local citizens involved in the tree planting activities.

Success and performance of planting activity
In terms of growth performance the project was successful. Installations of facilities for irrigation and protection from livestock have been implemented and maintained regularly.

Factors influencing success/failure of plantation
This activity was initiated by local citizens and experts. Harsh climatic conditions and lack of enough labor resources were the main constraints in this activity.

Lessons learned
During the establishment of the plantation some problems related to labor mobilization from the settlements occurred. The site is located far away from town and in the beginning of the project income generating targets could not be realized on the ground.

The above described projects were supported by different NGOs from different countries who delivered technical and financial support for tree planting and reforestation activities according to interest of local citizens and organizations. However, the performance of reforestation activities implemented and assisted by the Mongolian Government is not known because of the general lack of reporting and monitoring of reforestation activities in the country.

Currently, the investment situation in tree planting activities is discouraging and indicates a negative net investment. Local mobilization of investment funds is very important in order to be able to meet at least part of future needs. And, in order to attract private sector participation it is necessary to provide investment profiles of suitable projects with relevant information and analysis.

It is necessary to have a balanced combination of funding sources to ensure stability of fund flow in tree planting. To avoid the fluctuations and to facilitate targeted funding for forestry, it will be useful to establish a National Forest Fund or National Reforestation Facility. The credit administration should have the capacity to see that the investment does not end up as failure. The autonomous enterprise systems will have the flexibility to administer such funds for reforestation activities in the country.

Introduction of comprehensive economic analysis to evaluate the forest rehabilitation's real contribution to the environmental protection, and thus increasing its leverage among decision makers, is necessary. It will also help to increase the use and adaptation of new and innovative financial instruments based on indirect benefits of forests.

Participation of public and private sectors, co-operatives, local organisations and groups need to be stimulated in order to achieve and maintain an increased level of investment in forestry and forest industry. Existing financial rules, controls and regulations should be improved and appropriate financial means and mechanism should be established/expanded to support small investors in forestry.

3. Forest Research Extension and Education

3.1 History of Forest Research Insitutions

Forestry research in the past was tuned to meet the needs of the State with regard to its responsibility for managing and administering the country's forests. The history of forest research institutions in Mongolia is briefly summarized as follows:

In 1956-1957, the nation-wide forest inventory was conducted by the Russian Forest Research Organization called "Forest Project Cooperation". It was the first investigation to describe the Mongolian forest resources, particularly wood supply for different economy sectors based on quantitative assessments. Since that time Mongolian foresters have started to be educated in forestry science in different institutes and universities of the former Soviet Union.

In 1958, the Mongolian Forest Inventory Expedition was established by using Russian forest inventory methodology and tools. Since this period the forest inventory expedition started to work as national forest inventory service. Main responsibilities of this organization are to survey forest resources in different regions of Mongolia and to estimate forest stocks by tree species and age classes for the purpose of forest resource exploitation preparing forest management plans for periods of up to 10 years.

In 1970, the Mongolian and Russian Joint Biological Expedition was started to investigate and describe the tree and forest distribution in various vegetation zones in high mountain areas of Mongolia and to study forest regeneration processes impacted by human activities such as logging and forest fire. During this scientific work several different studies were conducted in the field of forest vegetation dynamics, forest soil classification, forest insects and pests, forest regeneration trends after forest fire and felling and silviculture practices in different forest areas.

In 1972, the Research Institute of Forestry and Wildlife was established under the Ministry of Forestry and Wood Industry. The work at the institute was organized according to divisions specialized in various fields such as silviculture and reforestation; forest economics; wildlife study; forest planning and projects, and wood research and forest products.

Since 1970, till very recently, the responsibility for research related to forestry, forest products and wildlife has been shared between the Forestry and Wildlife Research Institute (mainly with applied research) under the Ministry of Forestry and Wood Industry and the Institute of Botany (mainly with geo-botanical research) within the Mongolian Academy of Sciences, even though some amount of overlapping in their activities was unavoidable.

Based on the Minister's Resolution No.38 in 1980, the Research Institute of Forestry and Wildlife was reorganized as Research Institute of Forest Inventory and Wood Industry including the former Forest Inventory Expedition. Under this structure, the Institute had the mandate to carry out forest resource inventory, scientific and technological developments relating to the practical aspects of forestry and wood products. The Institute had 7 main divisions: Forestry and Wildlife Division; Division of Forest Industry; Division of Forest Economics; Laboratory of Wood Research; Bureau of Forestry Projects and Planning; Forest Inventory Expedition and Tree Garden Section. At that time some 70 people were employed in the Institute. Main objectives of research work were to design new models of wood products and to modernize and extend technology and techniques of wood processing and forest harvesting factories; to increase economic effectiveness of forest enterprises and improve administrative management and planning of enterprises; to develop coniferous tree planting agro-technology in nursery and in logged and burnt areas; to study regeneration processes in different forest types and to classify forest vegetation zones in accordance with vertical elevation of forest distribution in high mountain regions; and to study forest game resources including protection and rehabilitation measures.

With the reorganization and changes in the structure of different ministries starting at the end of the 1980s and in the early 1990s, the Forestry and Wildlife Research Institute (newly named) continued under the new Ministry of Nature and Environment with a reduced mandate by joining with the Meteorological Institute. Research responsibilities on wood products and forest harvesting were transferred to the Ministry of Light Industry.

In 1997, some of the research functions of the Forestry and Wildlife Research Institute were transferred to the Institute of Geoecology, and Forest Inventory Expedition was renamed as the Forest Management and Projects Centre under the Ministry of Nature and Environment. In 1997, with reorganization in the Mongolian Academy of Sciences, the Institute of Botany became a part of the newly formed Institute of Biological Science. According to Government Resolution in 2000, the Division of Botany under the Institute of Biology was re-established as separate institution under its former name Institute of Botany.

3.2 Current Situation of Research Institutions

The current situation of research institutions involved in forestry and related research, and their respective mandates, are somewhat vague **–** and in some cases duplicating **–** reflecting the problems related to the transition from a centrally planned to a market economy. There are several institutions in Mongolia concerned with research relating to forestry: Forest Management and Projects Centre within the Ministry of Nature and Environment; Institute of Geo-Ecology within the Mongolian Academy of Sciences; Wood Science Centre affiliated with the Ministry of Industry and Trade; Division of Forest Vegetation Dynamics of the Institute of Botany within the Mongolian Academy of Sciences; Department of Forestry of the Mongolian National University and Department of Wood Industry of the Mongolian Technical University. Complementary research works are being carried out by the universities in the field of forestry and forest products, often supported by government funding.

Various research studies on forest ecosystems of Mongolia, distribution of forest resources, dynamics of forest change and forest ecological characteristics of different forest types, scientific background for deforestation, forest rehabilitation and timber exploitation etc., have been carried out. The Foundation of Science and Technology is allocating certain funds each year to finance forest research projects.

Forest Management and Projects Centre
In 1997, the functions of the former Forestry and Wildlife Research Institute were split up and most parts of the research activities were transferred to the Institute of Geo-Ecology. The Centre retained responsibility for forest inventory expeditions, management of the arboretum and limited field trials. Most activities of the centre are related to forest resource surveys of different regions in the country and forest protection against insect calamities. The research role of the centre is now marginal.

Institute of Geo-Ecology
The Institute of Geo-Ecology was established in early 1997 as new research facility, responsible for research relating to land, water and forest resource management. The mission of the Institute is to:

- Carry out research projects and basic and applied investigations on the management of natural resources, land resources, water resources and combating land desertification in Mongolia.

- Assist in policy development related to the conservation, restoration, and proper management of natural resources and environmental protection; develop proposals and comments on issues of socio-economic relevance;

- Apply the research results in practice and conduct experimental work according to the needs and demands of stakeholders;

- Contact and cooperate with international scientific organizations and participate in networks of relevant scientific organizations;

- Conduct joint research and field surveys; arrange training courses, scientific workshops and conferences; and develop projects and scientific publications in cooperation with universities and scientific organizations.

Organically, the Institute is under the Mongolian Academy of Sciences and with affiliation to the Ministry of Nature and Environment. The budget for the Institute is provided from the National Science and Technology Foundation which is managed jointly by the Mongolian Academy of Sciences and the Ministry of Education.

The Institute consists of four main research divisions: forestry and wildlife; water and land resource management; basic ecological study including desertification issues. Some 86 people are employed in the Institute.

Wood Science Centre

The Wood Science Centre is under the Ministry of Trade and Industry with some linkages to the Mongolian Academy of Sciences. The main responsibilities of the Institute are:

- scientific determination of the rational use of wood resources *and*

- efficient use of timber through improved design of products and waste-reducing processing technologies.

The Centre has currently no adequate research facilities to carry out research activities.

Institute of Botany

This Institute of the Mongolian Academy of Sciences is involved in basic research work on: plant biodiversity, breeding of useful and medicinal plants, geo-botanical research and study on forest vegetation dynamics. Major forest research topics of the Institute of Botany include forest vegetation classification, impact of forest fire on vegetation, forest regeneration dynamics, studies on forest thinning/ tending, biological expeditions for vegetation distribution and its dynamics.

Some useful studies related to forest mensuration, silviculture and forest management are undertaken by the Forest Department of Mongolian National University. One forest station close to Ulaanbaatar belongs to the Forest Department and students are doing forestry practices during the summer season. Studies related to wood processing technology and tree harvesting are being carried out in the Department of Wood Processing Technology of the Mongolian Technical University. There is no involvement of the private sector in forestry research in Mongolia.

Some international projects partly related to forestry research include: GTZ project for Buffer Zone Development in Khan Hentey Special Protected Area, World Bank Project for Biodiversity Loss and Permafrost Melt Dynamics in Hovsgol Lake, JICA Project for Forest Management Study in Selenge Aimag (completed in 1997).

3.3 Legal Status of Forest Research

At the end of the 1990s the Mongolian Parliament passed the following laws and policies related to science and technology development:

- Law on the Status of the Mongolian Academy of Sciences, May 23, 1996
- State Policy on Science and Technology Development, May 14, 1998
- Mongolian Law on Science and Technology, May 07, 1998.
- Mongolian Law on Technology Transfer, May 07, 1998.

The state policy on science and technology indicates some basic principles of science and technology development as follows:

Activities of Science and Technology development shall be supported, coordinated and monitored by the state and public communities

- to support any activities by the private sector in the field of science and technology development;

- to harmonize government leadership and its self leading activities, to strive for decentralization in the field of science and technology;

- to accord strategy and priority of science and technology with social development phases, to develop appropriate science and technology strategies, and to keep a balance between fundamental and applied research;

- to maintain capability of science and technology achievements, to mobilize and motivate the capabilities of Mongolian scientists, to introduce advanced technology from the international scientific community;

- notwithstanding ownership type to arrange scientific and experimental activities, to ensure equality of rights and freedom of scientific institutions and scientists;

- to ban any experimental activities with negative impacts to national security, human health and environmental conditions;

- to provide transparency in the field of science and technology; *and*

- to finance research activities according to their significance, benefits and final outputs.

In general, the Mongolian Government is paying attention to develop science and technology in the country by allocating a total budget of about Tg. 1.5 billion annually for research.

3.3.1 Procedure of Research Project Implementation

According to the Mongolian Law on Science and Technology, research projects will be implemented on the basis of different funding sources depending on the type of the ordering organizations. This law indicates three main sources of funding:

1) state budget
2) local budget
3) ordering organization's own fund.

The research projects funded by the state budget should be implemented according to the Regulation of Scientific Research Project Implementation approved by the Government Resolution No 14. February 12, 1998.

Main stages of implementation of scientific research projects are:

- Ordering and announcement of a research project;
- Preparation of a research project proposal;
- Selection of project proposals through the National Science Council;
- Contracting and signing of research projects;
- Project fund allocation;
- Monitoring of research project implementation; *and*
- Reporting of research outputs.

3.3.2 Some Research Outputs in Forestry

In general, forestry research has a long tradition. The complexity of forestry and its long production cycle, which can last three or more times the professional life of an individual forester, requires research to be conducted by institutions to expand existing knowledge and discover new techniques which cannot be developed in day-to-day field work.

Nonetheless, over the last 20-30 years Mongolian forest scientists worked out several research outputs and publications. During the different structure of forestry institutions, scientists from above-mentioned research institutions passed many recommendations, instructions, findings and different publications to forestry practitioners. Last year, Mongolian scientists concentrated on the following fields of study:

- Agro-technology of breeding of coniferous seedlings in forest nurseries and greenhouses in accordance with tree seed genetics;
- Study on natural forest regeneration according to forest type and forest vegetation zones;
- Impact of logging and forest fire on the forest rehabilitation of natural forest stands;
- Study on forest growth trends of different species in the main forest types;
- Tree transplanting technology in sub-taiga forest zones;
- Research of forest fire impact on forest stand dynamics and tree resistance on fire disaster in the northern forest zone;
- Study on new design and new technology of wooden products in accordance with wood quality and tree species;
- Research of secondary forest products utilization for different purposes;
- Study on forest insect distribution and prevention measures in larch and pine forests;
- Agro-forestry research for the creation of green shelterbelts towards wind erosion protection in crop land area of Northern Mongolia;
- Selection of appropriate forest harvesting methods aiming at reducing the negative impact of logging;
- Research of thinning methods in young larch stands;
- Study on the hydrological role of mountain forests and changes of protection role after harvesting and forest fire;
- Study on the classification of forest in accordance with the protection function of forest stands;
- Methodology of breeding and planting of some species in the Gobi desert area of Mongolia;
- Dendro-chronological study on climate change in Mongolia;

- Research on forest inventory indicators of larch and pine stands; *and*

- Study on chemical components and physical quality of wood of different species.

As listed above, most studies concentrate on tree plantation and natural regeneration processes of different types of stands but very few studies are conducted in the field of silviculture and forest management and economics. Some results of past research work are illustrated in nearly 30 doctoral dissertations.

Several significant strengths which are important and relevant in supporting forestry research development of the country are:

- Existence of several research institutions and a number of well trained and committed scientists and technical staff with experience, whose performance can considerably be improved through retraining and in-service training;

- Existence of forest resource data of the whole territory of Mongolia, even though they could not be updated due to technical reasons;

- Availability of a fair amount of science and technology developments related to forestry, even though not all could be made operational due to various reasons;

- Useful information on land use and vegetation classes is available;

- A tradition and long history of forest management, even though currently in crisis;

- Existence of natural forests to support biodiversity and environmental objectives; *and*

- Existence of supporting institutions outside the forestry research institutions such as universities and relevant research institutes; and fruitful collaboration can be developed with them.

Most general problems and weaknesses in research are related to institutional aspects. Problems in research related issues are:

- lack of incentives affecting extent of research outputs and findings,

- financial constraints,

- lack of investment and transfer technology,

- need for in-service training to improve proficiency and outlook on advancing trends in forestry research,

- lack of integration between fragmented structural institutions,

- lack of adequately trained research scientists,

- lack of demonstration and dissemination of information,

- inadequate systems of forestry databases and statistics.

The above-mentioned conditions currently prevent the establishment of a clear research strategy and well defined research plan or priorities towards guiding forest sector development. In spite of resource scarcity, research activities are taken up on an *adhoc* basis, there is little coordination of activities, and this leads to large gaps in scientific knowledge. Very little or no work has been done on a number of crucial aspects. These, among others, include: socio-economic, policy and institutional aspects; forest mensuration; forest product standards; waste reduction and waste utilization; agro-forestry; non-wood forest products; forest recreation and eco-restoration; productivity improvement studies; wildlife management; forest genetics and tree improvement; plant/tree introduction trials; product diversification and product marketing.

Suggestions for resolving these problems include:

- identify needs of forestry research,
- develop forestry research strategy or and research plans,
- develop science based information networks,
- improve research facilities and increase investment to the prioritized research field,
- develop a human resources development plan for forestry research,
- create forestry research experimental stations,
- promote inter-institutional linkage between universities and research institutes,
- train and educate research scientists *and*
- develop international cooperation.

In any strategy towards improving the situation, it is necessary to clarify the role of public sector research in a market economy driven by private sector, and the procedures and safeguards for transfer of technology.

3.3.3 Human Resource Development

Inadequate capability in forestry is reflected both at the central and decentralized levels in the lack of human resource development for forestry, lack of facilities for forestry education and training, and inadequacies of statistical information required for proper planning and programming.

While the situation relating to forestry capability is unsatisfactory at the central level, in several *Aimag*s and *Soums* no forestry expertise at all is available, leave alone a critical mass. Since practical forestry is planned and implemented at the decentralized levels, this deficiency becomes all the more serious.

Human resources development, through its role in improving knowledge and capability, is a key factor in successful planning, implementation and monitoring of programs, projects, and activities. A motivated and skilled staff is essential to ensure efficient functioning of an institution. While motivation is influenced by material and non-material incentives, skill is a function of education and training, for continuous upgrading of capabilities.

The biological, ecological, economic and social dimensions make it necessary for forestry to be active in several interfaces, requiring multiple skills at various levels. Accordingly, there is the need for different types and levels of forestry education and training, under university and non-university systems, covering specialist, professional, technical and vocational requirements. Human resources development involves planning and management, relating to its quantitative and qualitative aspects, in both pre-service and in-service situations.

General aspects such as public education and awareness creation on the importance of forests, women in forestry development, and participatory approaches and community involvement in forestry are also relevant in the context of human resources development. Human resources development is a vital component of overall ‘capacity building’ which encompasses the country’s human, scientific, technological, organizational, institutional, and resource capabilities.

It is very difficult to get a clear view of the human resource situation in forestry in Mongolia. Relevant information is not forthcoming, as forestry activities are so dispersed and merged with non-forestry activities.

3.3.4 Forestry Education and Training

Until 1990, many forestry professionals were trained at postgraduate level in Russia, Poland, Bulgaria and Romania. At present, forestry education in Mongolia is concentrated at the Mongolian National University (forestry) and the Mongolian Polytechnic University (wood industry), in Ulaanbaatar. In forestry education, emphasis is placed on ecology and land use planning. In the wood industry curriculum, students can specialize either in mechanics or production technology. Both universities accept between 15 – 20 students each year. Additionally, Darkhan College provides courses for B.Sc. degree in nature protection for a limited number of students.

At one stage, in the past, there were 4 sub-professional and 5 technical training schools for forestry and forest industry in Mongolia. Due to lack of funding, these have been closed down. At present there are no facilities for in-service upgrading training or for training forest workers. Rangers, the lowest entry level in the government forestry service, often start as workers and then move up, based on experience.

MNE, including those of its affiliates, had a staff-strength of 1,578 in Ulaanbaatar as of June 1996 (ADB 1996). Of those, only some 10 to 20 persons were having forestry background. It is estimated that in Mongolia some 100 to 150 graduate foresters are actively engaged in the profession – i.e. in public sector, private sector, universities and research institutions. Overall, the human resource situation in Mongolian forestry is inadequate to support sustainable forestry development.

In order to compare different fields of graduation with forestry graduation the example is shown in Table 3. During the academic year of 2001/2002 there were 2355 graduated students from 7 state owned and 4 private universities. About 86.5% of those students graduated from the state university (23.1% – Mongolian National University; 40.1% – Agriculture University of Mongolia; 22.6% – Mongolian University of Science and Technology etc.), which proves that the role of public universities in educating professionals in the field of environment and ecology is still significant. In the private universities and colleges there were 318 (13.5%) students studying in this field.

Table 3: ***Graduation of Forestry Related Education in the Academic Year 2001/2002***

Specialization	Total students		2001 graduates		2002 graduates	
	Number	%	Number	%	Number	%
Ecology	304	12.9	51	13.2	44	13.2
Biology	313	13.3	113	29.4	89	29.4
Forestry	223	9.5	40	10.4	60	10.4
Geography	615	26.1	17	4.4	87	4.4
Botany	314	13.3	107	27.8	114	27.8
Rangeland	176	7.5	0	0	80	0
Nature conservation	193	8.2	0	0	33	0
Teaching of biology	217	9.2	57	14.8	68	14.8
Total	2355	100	385	100	575	100

The professions most in demand are geography and eco-tourism (26.1%), followed by biology, botany and ecology (approx.13% each).

However, the number of graduated students in the field of forestry is comparatively low (10.4%). It shows that although many people study in the general major of environment or ecology, very few students graduate with a specialized profession like forestry and nature resource management.

The low demand for the specialization of forestry and natural resource management among the graduated students proves poor working cooperation between forest agencies and the universities and educational institutes. In other words, the supply of human resources does not meet the actual demand because the policy of the Ministry of Nature and Environment on human resources for the forestry agencies/organizations has not been clearly defined.

Besides, due to the limited number of vacancies and budget stringencies of forestry agencies, low level of salaries, poor working and living conditions in the countryside and the absence of incentive mechanisms, new graduates are not attracted to the countryside and are only interested in staying in urban areas. In some cases, young graduates have difficulties in getting jobs in the forestry and forest industry sector, because the staff in the forestry agencies is not selected for their professional skills and other criteria on a competitive basis.

In the curriculum of the ecological programs of the universities and institutes, the class room based subjects make up a large portion and there is very limited portion of practical and field training courses. Therefore, newly graduated staff does not always meet the requirements and again must have on-the-job training to gain practical experiences.

3.4 Forestry Exentsion

The need for increased people's participation in forestry has been recognized with the National Forest Policy which is approved by the Government Resolution of 1998. A special section on people's participation and public awareness has laid down objectives, strategies and programs to mobilize people's participation in forestry.

In general, forestry extension is a means to inform and educate the masses on the values and importance of forests and to motivate them to participate in activities that lead to forest conservation and improvement of the social, economic and environmental conditions of the country. It also guides and helps people, particularly the unemployed and poor, to earn a better living without destroying the forests. Mongolia has a rather short history in applied forest research with very little development of integrated local techniques and methods for use of forest products at the community level. Last years community based forest rehabilitation work was initiated through UNDP projects. It was somewhat the initial stage of forestry extension.

3.4.1 Main Problems and Constraints in Forestry Extension Programs

The main problems in forestry extension are the lack of labor and the main reason for this is the poor wage and low income of local people. Labor migration for economic reasons is quite common in some areas of Mongolia.

Also, the design of forestry extension in Mongolia is a very critical issue. A country with vast land area and low population density requires a different model or design of forestry extension services. Important issues to be addressed towards this end include the following practical issues:

- Develop a land tenure system and identify a suitable land use system;
- Provide people adequate funding for forestry extension programs at local level;
- Allocate equipment and supplies as seeds, fertilizers etc.;
- Provide information and education through mass media and group media;
- Develop preliminary extension organizations at Soum and Bagh level;
- Provide forestry extension officers at least at Aimag level;
- Organize training and technical advise for forestry extension;
- Provide training facilities at local level;

- Develop a forestry extension program at national level; *and*
- Conduct agro-forestry research and circulate research findings.

3.4.2 General Recommendations for Forestry Extension Development

The creation of a forestry extension program is one important issue for sustainable forest management in Mongolia. In this case, the following activities are recommended:

- Develop forestry extension programs including preliminary organizations at local level with forestry extension officers and forestry extension assistants;
- Identify forest extension approaches, activities, methods and field procedures which extension staff can apply to convert programs and plans into effective action;
- Make assessment of forestry extension needs and identify problems and priorities;
- Choose the type of forestry extension;
- Provide information and education; organize awareness campaigns and promote mass media and group media among local people;
- Start forestry extension research, specially extension oriented inter-disciplinary research; *and*

Conduct research on agro-forestry and silvopastoral systems for the production of dry season fodder for domestic livestock.

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Forest Plantation after Fire Disturbance

Forest and Grazing in Mongolia

Rehabilitation of Russian Forests

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1. General Information

1.1 Geographic Information, Population and Natural Resources

The Russian Federation (Russia) is the largest country in the world. Its land area comprises 17,075,400 sq. km and covers 11 time zones (UTC +2 to +12). Counter-clockwise from northwest to southeast, Russia shares land borders with 14 states on land – Norway, Finland, Estonia, Latvia, Lithuania, Poland, Belarus, Ukraine, Georgia, Azerbaijan, Kazakhstan, China, Mongolia and DPR Korea, and 3 states across water – the Bering Strait, Baltic Sea and La Perouse Strait – with United States (Alaska), Sweden and Japan.

Figure 1: ***Russia in the World Map*** *(source: http://en.wikipedia.org/wiki/Image:Location_Russia.svg*)

Russia stretches from north (Franz-Josef Land Islands) to south (Russia-Azerbaidjan border) at 2,500-4,000 km and from the Polish border in the west to the Ratmanov Island (Bering Straits) in the east at 9,000 km. Russia's borders extend over a total area of 58,562 km with 14,253 km bordering other states and 44,309 km bordering the sea.

Russia is also rich in water resources with 120,000 rivers longer than 10 km comprising 13% of the global freshwater resources. The major river systems such as Ob, Irtysh, Yenisei and Lena in Siberia are located in the Arctic Ocean basin, in the European part – the Northern Dvina, the Amur, Anadyr, Penzhina and some other river systems flow into the Pacific Ocean. The Don, Kuban and Neva rivers flow into the seas bordering the Atlantic Ocean. Russia's main river, the Volga, flows all the way to the Caspian Sea. In total, Russian rivers stretch over 3 mill. km discharging nearly 4,000 cu km of water annually.

There are also numerous lakes in Russia especially in the northwestern part of the country. The largest lakes are located in the south: the Caspian Sea occupies an area of 371,020 sq. km, and Lake Baikal (30,510 sq. km), being the deepest (1,637 m) and the most volumetric (23,000 cu km) fresh-water lake in the world holding almost one fifth of the planet's fresh water resources. Next in size there are the Ladoga and the Onega lakes in the European part of Russia – fresh-water lakes of a glacial origin.

Mountains cover 52% of its territory. Major mountain ridges are the source of water to many areas in Asia, including Central Asian countries. On the southern border of European Russia are the geologically young Caucasian mountains stretching between the Black and the Caspian seas. The big Caucasian ridge partially is in the territory of Russia. The highest point of the country is an extinct volcano, the Elbrus (5,642 m) which is also the highest point of Europe. The Ural Mountains form the eastern limit of the Great Russian Plain, as well as the traditional boundary between Europe and Asia, and run for about 2,100 km from North to South. The highest peak, Mount Narodnaya, reaches 1,895 m, and the others range from 900 to 1,500 m. In the south of the Asian Russia there are (from the west to the east) the Altai

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and Sayan mountains, Yablonovyi and Stanovoi ridges (Davidova, M.I., et al., 1966; Rakovskaya and Davydova, 2003, Geography of Russia, http://www.georus.by.ru/).

As of 2006, the country's population is about 143 mill. people with a mean population density of 8.3 per sq. km, although 75 % of the population lives in European Russia and the rest in Siberia and in the Russian Far East comprising more than three quarters of the total territory of the Russian Federation. Russia is a multiethnic society. The largest ethnic groups include Russians (81.5%), Tatars (3.8%), Ukrainians (3%), Chuvash (1.2%), Bashkir (0.9%), Byelorussians (0.8%), Moldavians (0.7%), etc. Over 80% of the population name Russian - the official language of the country - as their native language. Other languages are used in ethnic minority regions. Russia is rich in religious diversity. The main religions in Russia are Orthodox Christianity dominated by Russian Orthodox Church and Sunni Islam. In total, over 150 confessions can be found across the country.

The Russian Federation (Figure 2) included 86 federal subjects, such as 48 oblasts (provinces), 21 republics (states) with numerous ethnic minorities, 7 krais (federal territories), 7 okrugs (autonomous districts), 2 federal cities (Moscow and St.Petersburg) and the Jewish Autonomous Oblast. From major divisions, federal subjects are grouped into 7 Federal Districts: 4 in the European part and 3 in the Asian part of the Russian Federation (http://upload.wikimedia.org/wikipedia/en/9/9a/Russia_Div.png).

The country possesses a wide array of natural resources including major deposits of oil, coal, natural gas, many strategic minerals, diamonds, and timber. The economic zone along the 37,653 km long coastline (Arctic and Pacific Oceans, Baltic, Black and Caspian Seas) holds significant reserves of fish, oil and natural gas on the sea shelf. Most of the country has a so called harsh continental climate characterized by a big difference between summer and winter temperatures (it gets indeed very cold in Siberia during winter, but it is also very hot in the summer). Russia's geographical location presents a significant obstacle to development. Dry or cold climate, difficult terrain conditions, distance and remote locations from major sea lanes are the reasons why large parts of the country have almost no population and development. Russia has only 8% of arable land but abounds in mineral resources whose total potential value is estimated at an impressive $30 trillion at current world prices. Russia produces 17% of the world's crude oil, as well as 25-30% of its natural gas, 6% of all bituminous coal, 17% of commercial iron ore and 10-20% of all non-ferrous, rare and noble metals mined across the globe.

Russia is one of the most forested countries in the world owning 23% of the global forests. The area of its forestlands comprises about 1.2 billion ha with about 0.8 billion ha of stocked forests, amongst which 289 mill. ha (25%) are virgin forests. Total volume of growing forests is more than 81 billion cubic meters. Russian forests are a significant carbon pool, and according to specialists, annual deposition comprises 650 Mt C/year (Russian Forests, 2005).

Mostly, Russia has turf and podzol soils. Black-soil regions can also be found here, with the richest soils in this category located in the steppes of southeastern European Russia, and along the Western Siberian Plain. Chestnut-colored, greyish-brown soils, as well as saline lands, are also located here. From the North to the South, Russia spans four climatic zones **–** arctic, sub-arctic, temperate and subtropical and could also be divided into the following vegetation zones (belts) – forest-tundra, northern, middle and southern taiga, mixed forests, forest-steppe, steppe and semi-desert (Figure 3).

The daily temperatures of January across the whole of Russia, except for the Black Sea coast of the Caucasus, are below zero centigrade, varying from -1 to -5 degrees C in the West of European Russia to -50 degrees C in Yakutia, where the record of temperature extremes is -62.1 degrees C in winter and +38.8 degrees C during summer time, i.e. the difference is about 101 degrees C (Parmuzin, 1985). The summer temperatures differ sharply between the North and South of Russia, from +1 degree in the North of Siberia to +25 degrees C in the Caspian lowlands. Rainfall is most plentiful (up to 2,000 mm a year) on the mountain slopes of the Caucasus and the Altai, followed by the southern areas of the Russian Pacific coast (up to 1,000 mm), where summer monsoon rains trigger frequent river flooding, and to a lesser extent, the forests of the East European Plain.

Forests cover some 40% of the entire Russian land mass. The largest forests can be found in the Siberian taiga, the Far East and the northern European territories. Mixed forests are typical of mid-Russian regions. The predominant tree species is larch, which occupies over 45% of the area (about 41% of the growing stock). About 90% of land covered with woody vegetation is occupied by the main forest-establishing species such as larch, pine, including Siberian cedar and Korean cedar, spruce, fir, birch, and aspen, grouped into coniferous, hard-leaved and soft-leaved forests. The remaining 10% are

Figure 2: ***Administrative Divisions of the Russian Federation*** *(source: http://upload.wikimedia.org/wikipedia/en/9/9a/Russia_Div.png)*

Figure 3: *Natural Zones*

made of thickets and other tree species such as creeping cedar, thicket-type birch, chestnut, pear, and others (Figure 4: Dominant Tree Species).

Almost 80% of forests located in the Asian part of Russia grow on permafrost and long frozen soils (Pozdnyakov, 1986). The permafrost is a global phenomenon; it occupies no less than 25% of the Earth's land area. In Russia alone the area of permafrost makes approximately 11.1 mill. sq. km; that is about 65% of its territory. The permafrost is a natural phenomenon of the northern hemisphere where most of the planet's land is concentrated. In Eurasia, the permafrost occupies about 13 mill. sq. km and stretches from sub-polar latitude up to 44 degrees north, and into the Tibet-Himalaya high-mountainous area, the permafrost penetrates up to 28 degrees north. In North America, the area of permafrost is about 7.2 mill sq. km. Its southern limits are traced in a range of latitudes between 52 and 56 degrees which is much more to the north compared with Asia. The reason for this difference is that the mountainous relief of Asia combined with cold climate, determines the southern position of the permafrost border (Konishchev, 2001). Due to this factor, most taiga forests are coniferous, and thus more adjusted to harsh climate and difficult growing conditions.

The largest share in terms of the area and stock of coniferous forests is held by larch growing mainly in the regions of Siberia and the Russian Far East on the area of 261 mill. ha (52% of the forests area) with a growing stock of 23 billion cubic meters (40%). Pine forests occupy 115 mill. ha (22.5%) with a growing stock of about 15 billion cubic meters (26%) and 65% of their area is located in the Asian part of Russia. Spruce and fir forests cover almost 89 mill ha (18%), with a growing stock of 12 billion cubic meters (21%) and more than 52% of these forests grow in the European-Urals part of the country. The area of cedar forests growing mainly in Siberia and the Russian Far East amounts up to 39 mill. ha (almost 8%) with a growing stock of over 7 billion cubic meters (13%). In the hard-leaved forests 48% of the area is occupied by the Far Eastern birch. The most valuable species of this forest include oak and beech which occupy 4 mill ha. In the deciduous forest zone 96 mill. hectare (78%) with a growing stock of about 10 billion cubic meters (71%) are occupied by birch forests while 20 mill. ha (16%) with a growing stock of 3 billion cubic meters (22%) are made up of aspen forests (Roshchupkin, 2003; Russian Forests, 2005).

In the Far Eastern and Siberian regions the natural forest stands still remain highly productive. They have not earlier been under anthropogenic influence and can be considered as an example of modern forest management. Middle-aged and mature forest stands are mainly formed after gradual harvesting. The quality of harvesting operations along with its conformity to natural succession cycles of the forest are the main determining factor of further restoration and a subsequent development of forest stands. The formation of young growth occurs basically with tree species composition change. Therefore, the success of targeted tree species restoration depends largely on the type and efficiency of silviculture treatment of young forest re-growth.

In the Far East the four most important timber species are: spruce-fir, larch, oak and ash forests.

The Far Eastern green moss types of spruce forests are of mostly uneven-aged structure. Even after clear cutting with retention of medium-sized trees, middle-aged forest stands are formed. After several improvement felling operations the stands there are mostly 101-120 years old and ready for selective harvesting. Except for clear cuts, all types of felling operations allow to utilise most of the growth potential of the spruce-fir forest formations, without negatively affecting forest areas and protective properties of the territory.

From a genetic aspect, larch forests could be considered as radical and derivative. From forest typology, one can describe dozens of larch forest types depending on the structure, origin and conditions of wood growth. Larch forests in green moss groups of forest types are derivative and belong to fire originated lines of forests development nature. By means of gradual and long gradual harvesting methods, the process of restoration of radical forests could be considerably accelerated.

Oaks are the commercially most valuable tree species in the Far Eastern broadleaved-coniferous forests followed by ash stands. The majority of oak forests has evolved under fire influence and is characterized by a rather simple structure and tree species composition. The upper canopy layer is usually made up of an even-aged generation of oak trees, and in the lower layer there are linden, maple, Korean cedar and other valuable species. All forestry restoration activities in oak forests should be directed towards maintaining the multi-species structure through the careful application of gradual harvesting techniques.

Figure 4: ***Dominant Tree Species***

In the Far East ash stands are among the most complex in terms of stand structure and species composition. They are characterized by an uneven-aged structure and varying dominance of species. Selective harvesting methods are most appropriate to the nature of this forest formation.

Siberian forests grow under rather severe climatic conditions and are often poorly stocked. More than 30% of the forested area is considered low density, with a basal area of only 30%-50% the levels of normal stands. In these low density stands timber stocking is less than 80-100 cu m per hectare. The majority of these forest stands is located in East Siberia and the Far East. More than 40% of the Siberian forests are growing on poor sites, predominately in the Far East (Siberian Expectations, 2003).

According to the available information, the number of forest dependent species on the territory of the Russian Federation is as follows: trees and shrubs – 847, grasses and shrubs – 1,438, mushroom species – 212; forest fauna: mammals – 127 and birds – 158. The Red Book of Russia contains 247 species of fauna and 533 species of flora. Only part of them can be related to forest ecosystems (Filipchuk et al., 2003).

The most important causes of deforestation in Russia are forest fires and clear cuts. Other deforestation causes include pest outbreaks, inappropriate timber harvesting techniques and Illegal activities in forests, lack of legislation and unregulated recreation in urban forests.

However, Russia still has vast areas of old-growth forests available for harvesting. Mature and over-mature stands are dominating in every group of forest types throughout the Russian Federation (Figure 5).

1.2. Economic Situation and Environmental Issues

Russian economic growth and investment accelerated notably in early 2007. For the first time in years, manufacturing posted a very impressive growth relative to the same period in 2006, although at least some of the factors supporting manufacturing were temporary in nature. The investment boom has continued into the second quarter of the year, and 2007 looks to be a year of relatively rapid economic growth for Russia (World Bank, 2007).

Table 1: ***Main Macroeconomic Indicators of the Russian Federation (2001-2007)***

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2001 4M**
GDP growth, %	5.1	4.7	7.3	7.2	6.4	6.7	n/a
Industrial production growth, y-o-y	4.9	3.7	7.0	8.3	4.0	3.9	7.5
Fixed capital investment growth, %, y-o-y	8.7	2.6	12.5	10.9	10.5	12.6	19.9
Federal government balance, %, GDP	3.0	2.3	1.7	4.2	7.5	7.5	5.9
Inflation (CPI), % change, y-o-y	18.6	15.1	12.0	11.7	10.9	9.0	4.0
Current account, billion $	35.1	32.8	35.9	60.1	86.6	94.5	21.8*
Reserves (including gold) billion $, end-o-p	36.6	47.8	76.9	124.5	182.2	303.7	369.1
* Data for the first quarter; Source: Rosstat, Minfin, CB							

Figure 5: *Area Distribution by Dominant Age Class (Years)*

The Russian government has approved and submitted to the Duma its first three-year budget which represents important progress in increasing the horizon of budgetary planning. It has also changed the rules for the management of surplus oil revenues, and will divide the Stabilization Fund into a Reserve Fund for insuring the budget against fluctuations in oil prices and a Fund for Future Generations, which will be invested in longer-term assets. However, questions and controversies persist over the investment strategy and potential uses for the Fund for Future Generations.

The performance of the Russian economy since the 1998 crisis has been impressive. Between 1998 and 2006, Russian GDP expanded by an estimated 57.6%, while real income of the population grew by 65%. Poverty (headcount) rates were cut in half and regional disparities declined somewhat. Unprecedented macroeconomic stability was achieved in the context of strong budgetary and current account surpluses. Important reforms in areas such as taxation, budgetary institutions, and the removal of administrative barriers to business facilitated the rapid development of market institutions in many areas. The pace of growth began to slow down in 2001 and 2002, along with a steady weakening of the factors that supported the initial growth, although a major strengthening of oil, gas, and other prices on Russia's commodity exports gave a new boost to economic growth since 2003. Modernization and productivity growth outside the oil and gas sector have also been important contributing factors to the recent expansion.

The positive recent trends in GDP growth, investment, budgetary surpluses and poverty reduction have continued in 2005 and 2006. According to official estimates, GDP, fixed capital investment, and disposable income grew by 6.4, 10.5 and 9.3% in 2005, respectively. Preliminary estimates put GDP growth close to 6.5% during the first half of 2006. High oil, gas, and other commodity prices boosted Russia's economic prospects not only in the short-term. Most international investors have revised upward their expectations of these prices in the medium and longer term, thereby increasing the perceived attractiveness of Russia's rich and largely untapped resource base. The continued responsible conduct of macroeconomic (stabilization) policy has also improved the economic climate in Russia. In 2005-2006, a strong balance of payment inflows has been managed through prudent monetary policy and the accumulation of surplus revenues in the Stabilization Fund. This kept inflation and real appreciation at somewhat moderate levels and supported a record federal budget surplus estimated at 7.5% of GDP. An even higher surplus is expected in 2006. In January 2005, Standard and Poor's joined Fitch and Moody's in awarding Russia an investment grade rating. In September 2006, Standard and Poor's further upgraded Russia's sovereign rating.

Despite the country's strong economic performance since 1999, formidable challenges remain:

- ***Diversifying the economy.*** Greater diversification of the economy is needed to address poverty and inequality. While growth has been steady, it has been uneven, and poor regions and segments of the population have fallen further behind. Moreover, exports are largely commodity-based, and investments remain concentrated on the natural resource sectors. The high dependence of Russia's growth on prices for export commodities is undesirable in any case, but even more so in light of the goals of doubling GDP and reducing poverty by half. Success in achieving these goals would depend on scope and speed of diversification away from oil and gas and deeper into Russia's regions. The disparities in regional economic development in Russia could become an obstacle for fast economic growth at the federal level.

- ***Improving competitiveness.*** The weak system of financial intermediation, decaying transport infrastructure, continued dominance by unreformed natural monopolies, and delayed privatization of agricultural land must be tackled to improve the competitiveness of the economy.

- ***Encouraging the growth of small and medium enterprises.*** Small and medium enterprise growth has been anemic and needs to be encouraged to ensure that growth is more broad based.

- ***Building human capital.*** Access to high-quality education and health care is still limited, and there is a growing risk of an HIV epidemic. Building the country's human capital is an essential prerequisite for economic growth.

- ***Improving governance.*** Institutional capacity continues to be important for Russia. Governance is still a serious issue that needs to be addressed - not only corporate governance in the narrow sense of how commercial entities are created and run, but governance in the broader sense of drawing clear demarcation lines between the public and private sector, and setting rules for all parties on how to live within them (World Bank, 2006).

Meanwhile, there are regional peculiarities, especially in Siberia and the Russian Far East due to their geographical and natural conditions and historical development. For example, economic development of Siberia could be defined by three segments: natural-resource potential, industrial and scientific-educational potential and geopolitical position of the region (equally remote from western and eastern borders of Russia). One has got used to regard this medial location of Siberia only as the positive moment, but the duality of geopolitical location of the region consists of that it is equally remote both from western and eastern borders of the country, but is closed on the one hand, to the Arctic ocean, and on the other hand, to our southern neighbor. Because of this we bear huge transport loadings. Here we encounter are problems (Kuleshov, 2002).

In the Russian Far East, there is a necessity of getting the maximum value-added cost at elaboration of the projects. For this purpose, special attention needs to be paid to attract investments not for extraction, but for the processing of minerals. The key factor limiting the economic development of the region is shortage of transport infrastructure. The development of new mineral deposits and processing of wood are dealing with the construction of new objects of transport infrastructure, and the regions cannot solve this problem without serious federal support. Besides, in order to successfully developing the Far East economy, it will be necessary to develop at the same time deposits that are located in the remote areas. According to the Ministry of Economic Development and Trade of the Russian Federation, the level of the Baikal-Amur highway (BAM) loading makes 12 mill. tons per year already at the capacity of 15 mill. tons. According to the Minister, after acceptance of the decisions to increase export duties on round wood since July 1, the export of timber from the Far East will obviously decrease. And with January 1, 2008 the stream of wood will turn in a small brook, unless it turns into illegal export. Therefore, the main issue is how to transform this sector from grey into a sector of value-added processing and how to increase its transparency. At regional level there is an urgent need to accept programs on primary wood processing to avoid unemployment and illegal wood exports (Gref, G., 2007).

Today, the Russian forest industrial complex (FIC) combines logging, pulp & paper and wood-processing industries, while forestry is represented by a system of state management of forest lands. The logging industry has always been one of the most important segments of the national economy, determining the level of social and economic development of regions and contributing to the increase in currency reserves from timber export. In early 2002 only 5% of logging and wood-processing enterprises within the FIC remained state-owned, while the other 95% were under private, stock or mixed forms of property. The total number of enterprises amounts to more than 30 thousand in all the regions of Russia. The number of employees amounts to about 8% of the total number of working age population in the country.

During Russia's transition to a market economy the rates of slow-down of the logging sector production were higher than that of the Russian industry in general. From 1988 to 2000 the rates of timber export, sawn-timber production, wooden plate, and pulp & paper decreased four-fold. The level of cost-efficiency in the forest complex decreased to 8 % during the same period while the majority of logging enterprises became unprofitable.

Today, the FIC of Russia consists of logging industry (logging and primary processing of timber); timber storage and timber transportation works, sawmill production, production of ply-wood, wooden chips and wooden fiber plates, joinery construction items (windows, doors, flooring, constructions), wooden packages, furniture, pulp and paper, and forest-based chemical industry.

Currently, forest production output ranks fifth in the Russian economy in terms of gross domestic product and forth in terms of export volume. In 45 entities of the Russian Federation the FIC output amounts to 10-50% of the total volume of industrial output (Roshchupkin, 2003).

Wildlife management in Russia is based on a system of protected areas, the status of which is defined by the Federal Law "On the Especially Protected Natural Territories" (1995). According to this Law "specially protected natural territories are parcels of land, water table and air space above them where natural complexes and objects, which have nature conservation, scientific, cultural, aesthetic, recreational and health-improving values, which are withdrawn by decisions of governmental bodies in full or in part from economic use and for which the mode of a special protection is established".

Russia has inherited from the USSR the rather complex system of PA categories, which was formed in an evolutionary way. Under the Law the following categories are allocated: the state natural reserves (zapovedniks), including biosphere ones; national parks; natural parks; state wildlife refuges (zakazniks); nature sanctuaries; dendrology parks (arboretums) and botanical gardens; and health-improving areas and resorts.

All in all, the turbulent political, social, and economic circumstances of the post-Soviet period have confirmed that Russia's protected area system is incredibly robust. Not only did it manage to withstand such blows that many observers would assume would be lethal; it has, indeed, expanded greatly after the Caracas Congress. With 26 new nature reserves founded and 20 existing enlarged between 1992 and 2003, Russia currently devotes more area than any other country to what the IUCN calls "Category I Protected Areas". Russia's own national parks (which have expanded almost twice since 1992) add another 7 mill. hectares to its protected area system (i.e. From Caracas to Durban, 2003).

Today, Russia has 100 fully protected nature reserves with a total area of 34.2 mill. hectares, 35 national parks (6.9 mill. ha), 31 nature parks (13 mill. ha), 71 wildlife refuges (zakazniks) of federal importance (12.5 mill. ha), 2500 wildlife refuges of regional importance (45.3 mill. ha) and 9000 nature monuments (4.2 mill. ha), thus, in total 116.1 mill. ha (Figure 6; Russian Forests, 2005). Overall, the system of Russian protected areas including all categories of protection from local to federal level comprises over 15,000 PAs and covers the area of about 140 mill. ha, or more than 10% of the Russian territory (Blagovidov, Ochagov, Ptichnikov, 2002).

Distribution of protected areas across the country is uneven. For example, in Siberia and the Far East, there are 46 strict nature reserves (46% of total in Russia), only 6 national parks (17% of total) and 26 wildlife refuges of federal importance (37%).

The system of Russian state nature reserves is recognized all over the world. Twenty-one reserves have the international status of biosphere reserves, seven are under the jurisdiction of the World Cultural and Natural Heritage Convention, ten are under the jurisdiction of the Wetlands Convention of international importance, especially as being considered to be Waterfowl Habitat, and four zapovedniks have been awarded European Union Diplomas (Russian Forests, 2005).

Environmental conditions in Russia differ according to region. Ecologically problematic are: air pollution from heavy industry and electric power plants burning coal, transportation in big cities; industrial, municipal, and agricultural pollution of inland waterways and seacoasts; soil contamination and erosion; radioactive contamination of forests and lands in a few regions after the accident at the Chernobyl nuclear power plant and the tests of nuclear weapons by the military; groundwater contamination from toxic waste; deforestation and forest and turf fires.

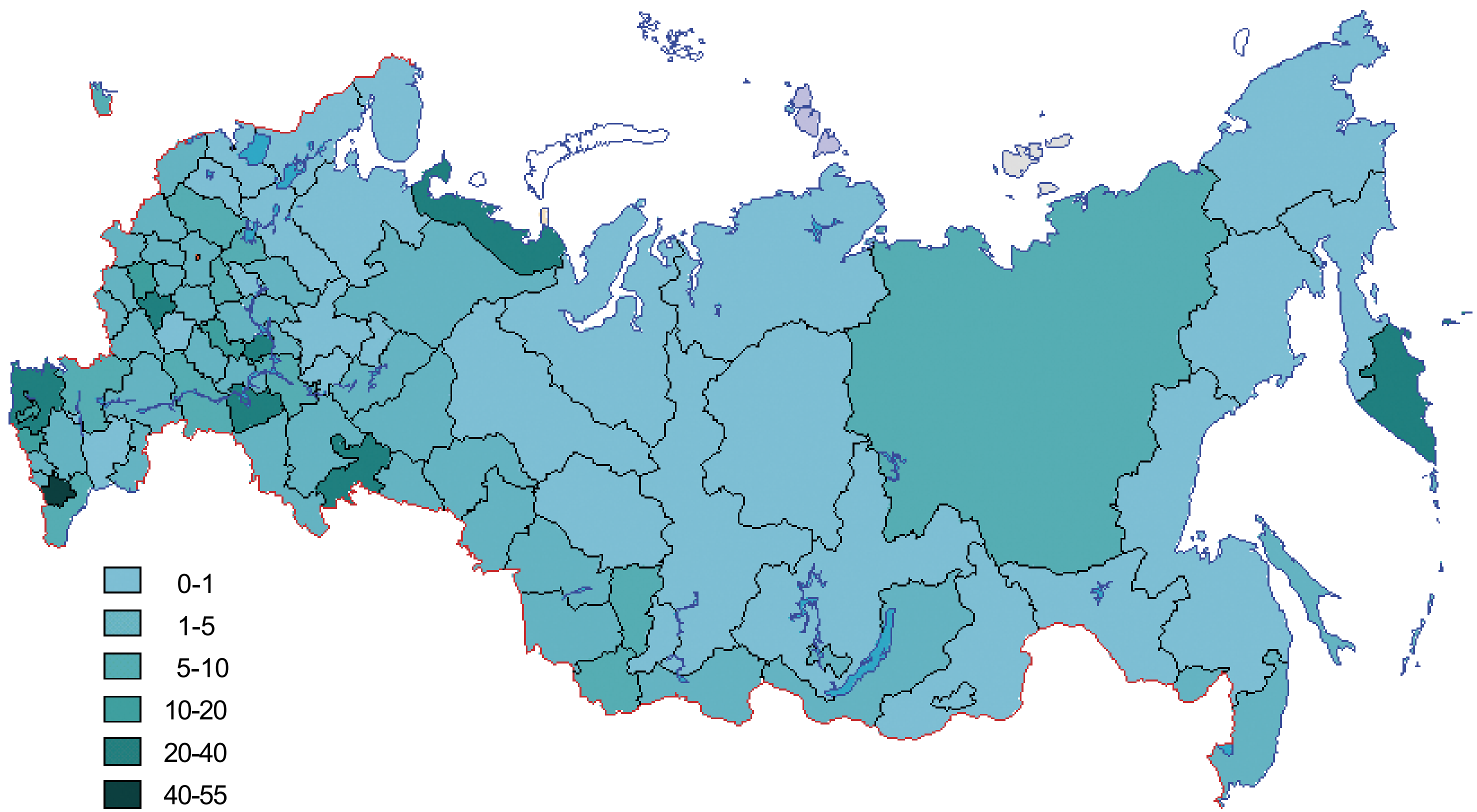
1.3 Current National Policy and Legislation

Until recently, Russia's forest policy did not differ much from the requirement declared by the state 300 years ago, which is to satisfy all its needs in timber. It was founded on the principles of state centralized management of forests. Throughout its history, Russia has paid attention to forest rehabilitation and afforestation. Annual reforestation rates slightly exceed the clearcut areas and new forests have been planted in areas where forests existed a long time ago or even in locations which were never forested before. Forest restoration after clearcut areas became obligatory under the forest legislation. New forests were planted in vast areas in the treeless southern region to protect the soil from erosion and deterioration. Much attention was also paid to forest reclamation after coal and mineral mining. All these activities became possible because of sound forest research, technical development, education and training.

The current national policy is reflected in Article 1 of the Forest Code of the Russian Federation (2007). Out of 11 key principles about one half deal with sustainable forest management, environmental values of forests and forests regeneration: "The following principles shall underpin forest legislation and other enactments governing forest relations:

1) sustainable forest management, biological diversity conservation in forests, and enhancement of their potential;
2) maintenance of habitat-forming, water conservation, protection, sanitation, recreation and other

Figure 6: ***Protected Area Relative to Total Forest Area (%)***



beneficial forest functions, to ensure that each person could benefit from a healthy environment;

3) use of forests with due regard to their global environmental significance, as well as taking into account the length of their cultivation and other natural properties;
4) multiple-purpose, sound, continuous, non-depleting use of forests to satisfy society's needs for forests and forest resources;
5) renewal of forests, improvement of their quality and yield;
6) ensured protection of forests;
7) participation of citizens and civil society associations in decision-making which may affect forests when they are used, protected and renewed, with procedures for and forms of such participation to be compliant with the legislation of the Russian Federation;
8) forest use by methods which are not detrimental to the environment and human health;
9) division of forests according to their designation, and establishment of categories of protection forests depending on beneficial functions they perform;
10) inadmissibility of forest use by public authorities and local self-governance bodies;
11) payment for forest use" (Forest Code, 2007).

Concerning forest rehabilitation, the Forest Code contains a separate which is dedicated to forest renewal and afforestation.

Article 61. General Provisions on Forest Renewal

1. Removed, dead, and damaged forests shall be subject to renewal.
2. Forest renewal shall be ensured through reforestation and forest tending.
3. Forest renewal shall be ensured by the public authorities or local self-governance bodies within the limits of their powers defined in Articles 81 - 84 of this Code unless otherwise provided for in this Code and other federal laws.
4. Failures of citizens and legal persons who use forests, to comply with the forest management regulations and forest development plans with respect to forest renewal shall provide a reason for dissolving their lease agreements for the forest parcels or sale-purchase contracts for forest stands prior to their expiration as well as for forced termination of their rights for permanent use of the forest parcels (use for indefinite periods) or the rights for gratuitous use of the forest parcels during established periods.

Article 62. Reforestation

1. Reforestation shall include natural, artificial or mixed restoration of forests.
2. Within forest parcels leased out for wood harvesting, reforestation shall be undertaken by lessees of these forest parcels.
3. Reforestation rules shall be established by the authorized federal executive body.

Article 63. Afforestation

1. Afforestation shall be employed to prevent water, wind and other erosion of soils, to establish protection forests and for other purposes related to the enhancement of forest functions.
2. Afforestation rules shall be established by the authorized federal executive body".

It should be noted that the term "reforestation" is not defined in the Forest Code of 2007, although it was not defined either in the Forest Code of 1997 (Forest Code, 1997; 2007). As can be seen from the above, reforestation is a means of reproduction of forests (Article 61, 2) and carried out by three different techniques (Article 62, 1). The regulations of reforestation and afforestation are a subject of federal body's jurisdiction.

According to the new Forest Code of the RF (2007) reforestation, land reclamation and other rehabilitation activities are a responsibility of the company (timber harvesting, mining, etc.).

1.4. Causes of Forest Degradation

Forest degradation in Russia is defined as follows: "Gradual loss of viability and dying off of forests as a result of deterioration of the ecological condition of the forest environment under influence of anthropogenic or natural factors" (Terminological Glossary, 2002, p.69) According to this definition, degradation of forests due to natural factors in Russia is estimated at an annual average of 0.7-2.5 mill. hectares after forest fire events and up to 0.1 mill. hectares due to pest outbreaks. Anthropogenic influences are responsible for a mean deforestation rate of 0.6-1.2 mill. hectares. This includes also unaccounted losses due to bad timber harvesting techniques and illegal activities in forests associated with recreation. Overall, forest degradation is indirectly caused by lack of appropriate legislation, poor administrative reform and inadequate management in the forest sector.

Today's problems of forest degradation were also discussed during a number of workshops in Russia (Deutz *et al*., 1999). The results of the workshops have shown that despite vast resources and the global demand for forest products, the Russian forest sector has been experiencing severe management problems that threaten both the socio-economic stability and the ecological integrity of the forests. The legacy of centralized planning policies, the recent transition to a market economy and ensuing economic and political turmoil have significantly diminished Russia's management capacity.

These problems are further compounded by insufficient public access to information and by the lack of mechanisms for public participation in decision making. These issues are severe impediments to the conservation and sustainable development of Russia's forests, and they urgently need to be addressed. The workshops employed participatory methods to enable the Russian stakeholders to articulate what they saw as the major obstacles and opportunities facing forest conservation and sustainable development in each region of Russia.

Among the issues identified in the Russian Far East workshop there are also some dealing with forest degradation:

- The absence of efficient methods for preventing and extinguishing forest fires.
- The need to increase the number of ecological parameters in and accuracy of forest inventories.
- The impact of logging on forest ecosystems.
- The need to elaborate and introduce regional criteria and indicators for the sustainable use of forests.
- The need to develop effective legislation in forests formerly owned by collective farms and Soviet collective farms (kolkhoz and sovkhoz) and to improve their status and management.
- The many drawbacks in current methods for calculating the annual allowable cut (AAC).
- Illegal logging and the illegal trade of forest products.
- The need to prevent fragmentation of large tracts of forest.
- The problem of deforestation in permafrost areas.
- The lack of forest regeneration and the decrease of forest productivity.
- Social aspects, including traditional uses of nature by local and indigenous peoples.

Issues identified at the Siberian workshop (mentioned are only those that are not listed for the Russian Far East):

- Determining and assessing possible underlying causes of deforestation and forest degradation and their resolution.
- Evaluating factors causing the degradation of forest edges.
- Using timber damaged by forest pests, diseases and fires.
- Assessing the impact of forest fragmentation and the disturbance of the hydrological regime as a result of interference in water courses.

Issues identified for the European-Urals Region (mentioned are only those that are not listed above):

- Make the transition from "industrial" forest management to "ecosystem" management.
- Balance the ecological, economic, social, and cultural aspects of sustainable development and find solutions to the problems of the forest sector at the political level.
- Combat the degradation and decline of spruce and oak forests.
- Protect mountain forests.
- Create incentives for the sustainable use of forests.
- Coordinate the multiple-use of forests to reduce the negative impacts on them.
- Study the ecology of temperate and boreal forests.
- Allocate more funds to scientific research on forests.

Many other scientific studies are available on forest degradation. For the Russian Far East (RFE), for example, forests are a driving force behind regional development, a reason for establishing and maintaining new production plants, infrastructures and settlements. Meanwhile, the overwhelming majority of environmental problems originate in the process of forest resources use. The main issues are (Sheingauz, 1998):

- Conversion of forestland into arable lands in the course of history;
- Soil erosion and degradation;
- Land development based on an expanding timber industry;
- Inefficient use of timber resources at logging site as well as in processing (loss amounted around 25-30% of harvested wood stock);
- Obsolete, non-ecological technologies and equipment for timber cutting;
- Large areas of wild forest fires (annual average 400,000 ha), in such catastrophic dry periods in 1954, 1961, 1976, 1988 and 1998. The annually burnt area amounts to about 1-2 mill. hectares and is considered an event of global significance;
- Pollution of water and disturbance of fish resources.

Frequently, destructive timber harvesting activities, industrial pollution or pest and diseases prevent forest areas to regenerate naturally, thus large areas become deforested. This has led to significant changes in the structure and composition of forests in Southern Siberia. In order to maintain the economic value of the forests and preserve its vital environmental functions, the management of forests in Southern Siberia needs to be based on natural regeneration of native tree species (Pavlov, 2007).

It should be mentioned that forest fires in Russia are anthropogenic factors (i.e. humans are to blame for over 82.5 % of all ignitions). 14.5% of all forest fire incidences are caused by lightning while about 3% of fires start for unknown reasons (Table 2). Lightning is the main fire-generating factor in the remote taiga areas of Siberia and in the Far East. In 2001, for example, lightning accounted for 94 % and 59 % of fires in the Evenki District and in the Republic of Sakha (Yakutia), respectively. After 1990, the number of fire incidences caused by forest logging declined because of lower harvest volumes obtained in final cutting operations (Shchetinsky, 2006).

Table 2: ***Key Causes of Forest Fires in Russian Forests, % of the Annual Number of Forest Fires by Selected Years (1985-2006)***

	1985	1990	1995	2000	2006
Agricultural burning	7.3	7.2	3.1	7.0	12.0
Forest logging	2.9	2.4	0.8	0.6	n/a
Survey/exploration parties	0.9	0.7	0.1	0.1	n/a
Civil and other works	5.0	4.2	1.6	3.2	2.0
Population	64.8	64.3	81.8	72.1	70.0
Lightning	16.0	17.5	10.7	14.0	n/a
Unkown causes	3.1	3.7	1.9	3.0	n/a

On average, the main causes of forest fires can be classified as follows:

- anthropogenic origin - 75%
- prescribed burning for agriculture - 5%
- lightning - 7%
- others - 13%

Anthropogenic influence is more obvious in European Russia with up to 100% of all incidences. Lightning is the most significant factor in Siberia and the Russian Far East where it causes up to 40% of wild fires. Records of the last 10 years reveal the following trends in fire occurrence (Russian Forests, 2005, Shchetinsky, 2003, 2006) as shown in Table 3.

Table 3: ***Fire Occurrence in the Forests under the Russian Ministry of Natural Resources (1997-2006)***

Year	Number of forest fires, '000	Burned area, '000	Losses from forest fire, billion rubles
1997	20.1	640.0	n/a
1998	24.2	2,458.0	5.2
1999	31.6	678.0	1.9
2000	18.7	1240.4	3.4
2001	20.9	868.2	2.4
2002	37.4	1,334.7	3.9
2003	27.8	2,099.6	2.3
2004	16.0	370.0	2.0
2005	22.2	442.2	1.9
2006	32.5	2,450.2	n/a

According to information from the Russian Forest Fund, in every decade two or three severe fire seasons tend to occur. They are associated with extreme weather conditions. In such years, forest fires turn into a natural calamity mostly affecting three or four regions of Russia where most adverse weather conditions occur. In this decade, the most complicated situation has been faced in the boreal forests of Siberia and the Far East which are increasingly exposed to intensive industrial and economic activities related to the development of oil and gas deposits, and in areas adjacent to the Trans-Siberian and Baikal-Amur Railways.

Fires in the northern taiga area sometimes account for about 20-30% of the total number of forest fires in Russia and 75-95% of the total area burnt. In 2003, the total area burnt in five Federal Districts accounted only for 1.67% of all fires, while in Siberia and the Far East the figure was 73.35% and 25.0%, respectively. In 2006, these figures on area burnt were 35.56% and 55.80%, accounting for 31.32% of the total number of forest fires in Russia in that year.

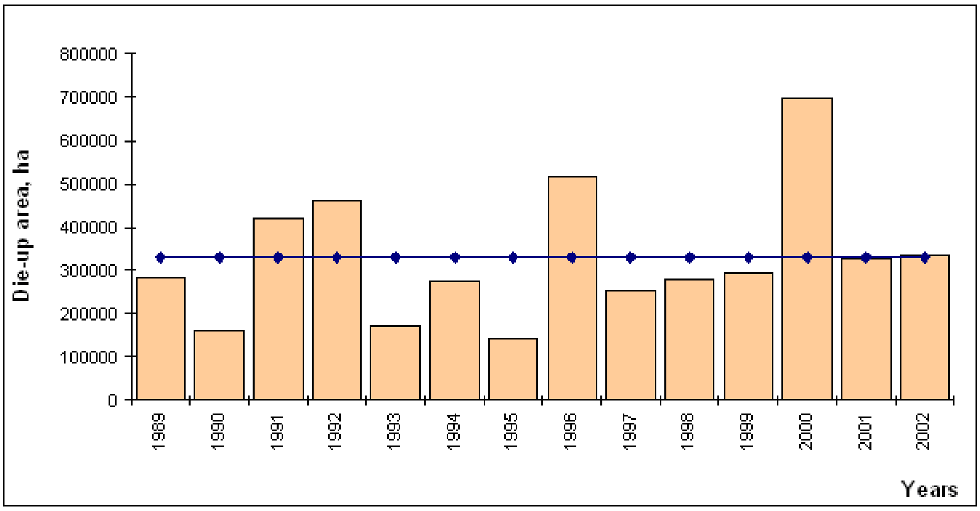
Losses from forest fires of recent years include: the cost of burnt down and damaged standing timber stocks (25-28%); burnt buildings, facilities and harvested timber (0.5-2%); fire fighting costs (31-33%); costs of fire site clearing (27-29%), and reforestation costs (11-14 %) (Shchetinsky, 2003, 2006).

Since 1989, the Russian Federation has been keeping a sufficiently comprehensive record of the stands perished due to adverse impacts. As per the official reporting requirements, the adverse factors responsible for stand mortality are classified into the following 6 large groups: fire, insects, wildlife (ungulates and rodents), diseases, weather conditions, and anthropogenic factors.

According to the data presented in the Forest Health Review, annually, forests on an area of 342,800 ha on the average were killed by various mortality factors, with a rather significant contribution of forest fires in some years. About 80% of them included coniferous forests. In 1992, 63.6% of the forests died, and in 2000, these factors were responsible for tree dieback in the amount of 91.1% of the total area affected that year.

The figure below provides an overview of the scale and causes of forest mortality in the period from 1989 to 2002. The blue line shows the annual average (Figure 7) (Mozolevskaya, Matusevich, Kobelkov, 2003).

Figure 7: *Area of Perished Stands (1989-2002)*



In 2002, the area of perished stands totalled 334,600 ha, including: 261,000 ha of coniferous forests. Over 68 % of these forest stands are located in the Siberian and Far Eastern Federal Districts. The level of forest mortality is above the 2001 forest death rate by only 2%, and by 4% below the average value over the recent decade (i.e. 347,500 ha).

Like in previous years, *forest fire impact* in 2002 has been the most destructive factor. Forest fire killed over 286,000 ha of forests or more than 85 % of the total area of perished stands for that year (see Table 1). This factor was recorded to cause the death of forest trees in 73 regions of Russia from the Kaliningrad Oblast to the Chukotka Autonomous District. In 2002, the largest area of forest stands perished due to forest fires was registered in the Asian part of Russia: Kamchatka Oblast and Koryak Autonomous District (61,300 ha), Republics of Sakha (52,100), Tyva (43,100), as well as Amursk Oblast (25,300) and Yamalo-Nenets Autonomous District (23,300 ha) (Mozolevskaya, Matusevich and Kobelkov, 2003).

Table 4: *Areas of Perished Stands by Cause of Mortality, 2002*

Cause	Forests under MNR, hectares	% of damage	Incl. Siberian and RFE Federal Districts from the cause total	Siberian Federal District, hectares	% of damage	RFE Federal District, hectares	% of damage
Damages by insects	21,066	6.3	33.6	5,373	25.5	1,701	8.1
Damages by wildlife	207	0.1	28.5	59	28.5	-	-
Disease	8,043	2.4	5.8	365	4.5	105	1.3
Adverse weather conditions	16,401	4.9	10.7	945	5.8	805	4.9
Forest fires	286,032	85.5	76.8	65,060	22.7	154,485	54.0
Anthropogenic impact	2,585	0.8	40.0	592	22.9	443	17.1
Industrial emissions	294	0.1	97.6	287	97.6	-	-
Total	334,628	100	68.8	72,681	21.7	157,539	47.1

As of the end of 2002, outbreaks of dendrophilous insects and diseases were recorded on an area of over 8,020,600 hectares, including 1,122,100 hectares in need of active pest control interventions in

2003. In 2002, the forest pest infestation area declined by 2,369,600 hectares, compared to the previous year. This was mainly due to the natural recession of the *Dendrolimus sibiricus* mass outbreak in the Republic of Sakha (Yakutia) and that of the *Dioryctria abietella* in the Republic of Tyva.

In 2002, outbreaks of defoliating insects feeding on conifers were the most wide-spread among all the forest insect and disease outbreaks. They were active on an area of 5,229,400 hectares (i.e. over 65 % of the total area of active outbreaks). The gravest threat to the life of trees was caused by mass outbreaks of *Dendrolimus sibiricus* affecting an area of 4,778,700 hectares in the Siberian and the Far Eastern Federal Districts, with the most extensive of them being registered in the Republic of Sakha (Yakutia) (4,350,100 hectares) and in the Khabarovsk Kray (232,500 hectares). Over the recent three years, the area of Panolis *flammea* outbreaks has enormously expanded (i.e. by more than 6 times). Currently, the affected area is 194,500 hectares, with 99% of them located in the forests of the Altai Kray (Mozolevskaya, Matusevich and Kobelkov, 2003).

Natural disturbances like pest outbreaks, droughts, hurricane winds, floods, etc. are also a major factor in forest degradation. For example, during 60 years about 550 floods, including 54 of catastrophic scale were observed in the Amur river basin. During two months in spring 1928, there was a big catastrophic flood when water fully deluged all settlements, eleven of which were completely flushed out. According to Alekseev (1998), an increase in forest lands in many parts of Russia is needed to avoid major natural calamities.

“When the Italians of the Alps used up the pine forests on the southern slopes, so carefully cherished on the northern slopes, they had no inkling that by doing so they were cutting at the roots of the dairy industry in their region; they had still less inkling that they were thereby depriving their mountain springs of water for the greater part of the year, and making it possible for them to pour still more furious torrents on the plains during the rainy seasons…

…The animal merely *uses* its environment, and brings about changes in it simply by its presence; man by his changes makes it serve his ends, *masters* it. This is the final, essential distinction between man and other animals, and once again it is labor that brings about this distinction. Let us not, however, flatter ourselves overmuch on account of our human victories over nature. For each such victory nature takes its revenge on us. Each victory, it is true, in the first place brings about the results we expected, but in the second and third places it has quite different, unforeseen effects which only too often cancel the first…” (Engels, 1876).

1.5. Terms and Definitions

Russia has a well developed system of definitions (Terminological Glossary, 2002). Forest degradation and rehabilitation could be defined in many ways by use of the following definitions.

Forest degradation – gradual loss of viability and dying off of forests as a result of deterioration of ecological condition of the forest environment under influence of anthropogenic or natural factors.

Forest re-cultivation (reclamation) – a set of activities aimed at restoration of productivity and economic value of the deteriorated sites, and also an improvement of environmental conditions. It is carried out in two stages:

1) The technical one includes the preparation of the grounds for their subsequent use. It includes a lay-out, formation of slopes, removal, transportation and bringing fertile soils on re-cultivated grounds, and, if necessary, a construction of the roads, special hydraulic engineering constructions, etc.
2) The biological one includes a set of agro-technical and phyto-amelioration activities for restoration of fertility of the deteriorated sites.

In brief, forest re-cultivation is planting trees on deteriorated sites after a technical stage of re-cultivation of the site (Terminological Glossary, 2002, p.332-333). Mainly, forest re-cultivation is commonly practiced in coal mining regions.

Renewal of forest is a process of the reconstruction of forest with all its characteristic properties, similarly to former or distinguished from previous ones. It is provided with a system of forestry activities for seeds gathering, establishment and maintenance of seed tree orchards and seed plantations, cultivation of planting material, creation of new forest, assistance to natural forest regeneration, thinning and tending in young stands, health improvement of forest etc. (*Ibid,* p. 47) It is the general term for forest rehabilitation in Russian language.

Reforestation is a general term for natural, mixed and artificial forest restoration. It is aimed at restoring of natural habitat conditions, structure and functions of forest ecosystem after disturbance.

Natural regeneration of forest is a process of continuous succession of woody vegetation in forest communities, and also a process of an occurrence and a development of forest in places where it was destroyed by virtue of natural or anthropogenic reasons. Renewal can be done by seed or vegetative propagation. According to its timing renewal can be preliminary, accompanying and/or the subsequent renewal (*Ibid,* p. 44).

Artificial restoration of forest (reforestation) is the creation of forest cover in areas that have not been covered by forest vegetation before (*Ibid,* p. 48).

Artificial cultivation of forest (*afforestation*) is the creation of forest stands in the areas which earlier have been occupied by forest (*Ibid,* p. 184).

Protective afforestation is the creation and cultivation of massive, group, strip and terrace forest plantations with the purpose of protection of an area against adverse anthropogenic influence, and also to increase the productivity of agricultural land (*Ibid,* p. 184).

Division of forest lands into districts is a territorial delineation of forests according to its natural and man-made conditions determined by forest forming species, types of forests, structure and productivity and forest restoration activities (*Ibid,* pp. 184-185).

Amelioration activities are the actions directed towards the protection of soils from adverse natural and anthropogenic factors and improvement of lands by creation of forest plantations and protective plantings of other woody species (*Ibid,* p.181).

2. Status of Forest Rehabilitation

2.1 A Brief Historical Essay on Forest Degradation and Rehabilitation

Russian people did not pay much attention to the forests due to their vast territories. It was common resource; nobody paid dues for forest use and services provided, and up to the end of the 17th century there was practically unlimited use of natural resources. For example, in the old chronicles, forest was mentioned extremely seldomly as a land category or part of other property. Forests were a natural element of the Russian landscape. Other more significant land-use categories were mentioned for their ability to give more value to the people's life of that time such as arable and hay lands, meadows, bee hides and beaver grounds. Only in territories where people were aware of the life supporting function of forests, for example, in steppe zones, forests found a reflection in the documents (Teplyakov *et al.,* 1998, Tarasenko and Teplyakov, 2003).

At the end of the 19th Century, the Russian writer Anton P. Chekhov wrote in a travel essay on the way to Sakhalin: "In the areas where there is no dense population, the taiga is mighty and unconquerable, and the words "Man is the King over Nature" sounds here more false and timid than anywhere else. If, say, the people, living along the Siberian border had agreed to destroy the taiga, by means of axes and fire, it would have the same outcome as the story about the titmouse who wanted to set the sea at fire".

During the 17th Century, timber was logged for constructions and energy use, for needs of metallurgy, potter, salt extraction, distilling and other crafts. Among wood-chemical manufactures the most wood consuming one was the potassium industry, and this kind of timber use was forbidden in selected areas such as abatises[1] and other reserved forests. Regional authorities were forbidden by the Council Code

[1] The abundance of forests enabled to create the elementary defensive barrier constructions – "zaseki" (abatises) – made from the trees fallen down against each other and performed as a strip of fallen trees.

of 1649 to independently allocate forest areas for potassium and turpentine factories. Despite of it, infringements occurred.

Baron Vrangel, one of the well-known specialists in forest legislation in Russia noted that “abundance of forests is the single most important reason for the late emergence of forest laws in the country” (Vrangel, 1841, p.2).

With the development of industrial consumption of wood and rapid deforestation of vast territories, leasing contracts for timber harvesting were introduced, and the legal rights of landlords were restricted. In this period, new categories of land tenure appeared such as production forests as secure raw-material sources for plants and factories, and also state (tsar) forests for shipbuilding.

Regular forest management began at the beginning of the 18th Century during the reign of Peter the Great. Peter I issued more than 200 Decrees on Forests. His Decrees of 1697-1703 were not of a nation-wide significance, although some of them were very progressive for Russia at that time (Red’ko and Red’ko, 2004). One of them was the Decree of 1701 which forbade clearing of forests for arable lands and haymaking on a distance of 30 *versts* (*versta* – an old Russian measure of length = 1.0668 kilometers) from floatable rivers. In 1703, the Decree on Stands and Trees valuable for shipbuilding introduced strict state regulation on forest use in the coastal zones of Russian rivers. Logging of the most valuable trees for shipbuilding was forbidden prescribing to establish reserved forests within a width of 50 *versts* along the banks of big rivers and 20 *versts* along smaller ones. The description of forest resources became a first step in their rational use. Infringements of the Decree were punished with the death penalty (Shelgunov, 1857).

In 1705, it was forbidden to “*burn grass in steppe, because it leads to damage of forests*.” That Act reflected the Tsar Alexey Mihajlovich’s, Peter the Great’s father interdictions concerning burning of grass close to abatises. As experience has shown timber residues left on clear cuts lead to pest outbreaks and damage of healthy trees.

Peter the Great could be considered as the first forester in Russia, because “forest management in Russia was founded by Peter the Great. Having created the Russian fleet, the immortal Reformer of Russia has looked at forests from the state point of view as a source of materials needed for shipbuilding. His reign was characterized by a rigorous forestry legislation accompanied by the threat of severe punishments ranging from high fines to penal servitude for life and even death penalty. At the same time, the aspiration of the government was not only to conserve the forests, but also to ensure the correct use of them as, for example, in the “Ober-waldmeister instruction, methods were prescribed for dividing production forests into annual cutting areas and even afforestation in the south by sowing acorns in the Azov and Astrakhan provinces” (Centenary, 1898, p.1).

It is also noteworthy to mention that Peter the Great was the first who introduced tree planting on roadsides, for both diversifying landscape and creating shelter for travelers, animals, birds. Later, this became common practice as protective strips along roads. For example, in 1701, along the road between Moscow and Voronezh (500 kilometers south of Moscow) milestones (poles) were erected between which on both sides of the road 10-20 young trees were planted, and their total amount comprised no less than 200 000 trees (Red’ko and Red’ko, 2004).

Forest regeneration could be linked with the German forester Ferdinand G. Fokel who had been working in Russia from 1727 to 1753. In 1738-1750, in Lindulovo near Saint-Petersburg, he established a shipbuilding forest “*Larch Grove*”, which still today is one of the great monuments to forestry endeavors in Russia, and nowadays this nature monument is under the aegis of UNESCO.

All measures undertaken by the Government at that time were not able to protect forests against devastation and did not meet the intended aims. German specialists brought to Russia and obliged to manage its forests made decisions (e.g. timber exploitation and conversion of forests to agriculture land) later considered as mistakes due to regulations prevailing at that time in Germany. They considered neither climate nor site conditions. They established forest stands only with major tree species without protecting them by less valuable species against harmful air and climatic conditions. There was also the wrong view at that time that shipbuilding forests could mature in Russia within 50 years. Due to this wrong assumption, the amount of wood available for harvesting was overestimated and after years of exploitation the forests were abandoned on vast territories. The creation of shipbuilding forests was stopped all together in 1759 during the reign of Ekaterina the Second (Vrangel, 1841).

Emperor Paul the First, in his decrees of March 12, 1798, on “forest management” and May 26, 1798 on “the management of all public forests and forest masters and rangers by the Admiralty Board,” initiated state management of the forests in Russia. During the first four years of the Forest Department, more than 70 decrees and commands were issued on forests.

In 1802, “The Charter on Forests” was adopted having three major goals: 1) Efficiently organize forest management for the protection and use of the forests; 2) End the shortage of timber “not only for the use of residents, but also for state and naval needs” and 3) In heavily forested areas of the country, make forests profitable for the state without endangering the livelihood of the people and without loss to the government. The Charter (Article 22) made into law the regulations on forests adopted under Catherine II which called for the sustainable use of forests: “commercial and state interests demand that the future abundance of the forests be ensured through a balance between harvesting and reforestation” (Centenary, 1898).

In the period 1826 to 1832, five different types of provinces were created, depending on their forest resources. Provinces were divided into regions, forest districts, forest blocks and forest sites. It should be mentioned that forest regions are divided into districts and blocks not primarily by size, but by their annual timber output and by the amount of forest preserved for shipbuilding and other uses (Teplyakov *et. al.,* 1998).

2.2 The Beginning of Afforestation in Russia

The establishment of a scientific school for afforestation and land amelioration specialized in forestry in steppe zone is connected to the name of its founder Victor Graff (1820-1867). In 1843-1845, for the first time in Russia, he has created 154 ha of protective forests in the feather grass dry steppe, in the Veliko Anadol Steppe and in the forest range of Mariupol District of the Ekaterinoslav province (nowadays the south of Donetsk area, Ukraine). “Where there was a burnt steppe – oaks now rustle”, the inspectors who have arrived from the capital in Ekaterinoslav province to check the progress of unique experiments reported to Saint Petersburg. Since 1874 it was considered as “exemplary”, and in 1974 this forest area of 2543 ha is preserved as an area of national significance.

Scientists had a long search for better composition of tree species, bushes and grasses at which Veliko-Anadol Steppe would turn in a uniform, steady ecosystem. The mixed stands of common oak, ash, maple, hornbeam, and linden are prevailing here. There are also birch, poplar, Crimean pine *(Pinus pallasiana)*, *Phellodendron amurense (Rupr.)*, European larch, Scots pine, Caucasian and chestnut oak (*Quercus macranthera Fisch, et May and Quercus castaneaefolia C. A. Mey),* chestnut, and *Saphora japonica (L.).* Graff established the nursery on an area of 54 ha; he planted 30 tree species and 40 bush species.

Graff has really made a scientific feat having created forest plantations capable of resisting droughts and dry winds in the southern provinces of Russia. The work of this outstanding scientist which was carried out almost for a quarter of a century under bad living conditions, frequently without the necessary financial resources, gave new scientific directions to the improvement of agro-landscapes.

Veliko Anadol forest has important forest functions such as water and soil protection as well as scientific and aesthetic values. Prof. Georgy Vysotskiy, the outstanding Russian soil scientist who developed the bases of agro-climatic classification of soils, established criteria of climate dryness and humidity, and the reasons why steppes are treeless. His research is closely associated with this forest (Mikhovich and Makarenko, 1964).

After the Emancipation Reform of 1861 the condition of the forests in Russia seriously deteriorated. Russian peasants comprising up to 90% of the population lived on state lands or on lands of private landlords, which were considered serfs (about 52 mill.). People received freedom and a piece of land, but the land issue provoked a wave of peasant actions, as the peasants received less land than they had had under serfdom.

Box 1.

Veliko Anadol Steppe Forest Area - is located in the Mariupol district Ekaterinoslav province and consists of six sites. On these sites about 25-50 versts away from each other forests have been planted. The largest of these sites – Velikoanadol (3100 desyatinas) is located on the Kashlagach gully, that is 10 versts from Velikoanadol station of the Donetsk railway and 90 versts from the district city away. At the beginning of 1891, there were 3392 desyatinas of artificial planted stands registered, although there are no natural forests at a distance of more than 30 versts even in valleys or gullies. The soil is rich, heavy, silty chernozem, with a depth of 1.5-3 feet, resting on yellow clay. Underneath is sandstone with layers of dark blue clay.

The Veliko Anadol Steppe forest area was established in 1843 by the former Minister of State Properties Duke Kiselev, who, surveying in 1840 Southern German colonies has paid special attention to the attempts of cultivation of forests in steppes and has wished to encourage Russian settlers to get involved in afforestation. But they considered this business as very difficult and unprofitable. Besides, it was desirable:

a) to prove an opportunity to grow trees under conditions of open steppe, about what at that time people did not consider feasible, because German colonists planted the tree groves mainly in the low, protected places;
b) to have all work done exclusively by Russian settlers;
c) to encourage the local population to get involved in afforestation;
d) to make various experiences of steppe forestation to develop the most reliable way of cultivation of forests in the steppe and to identify suitable forest species;
e) to acclimatize various forest and bush species to the steppe conditions, *and*
f) to improve, whenever possible, a steppe climate by cultivation of forests on large areas.

The management of a new forest range was entrusted to the young Victor von Graff who during more than twenty three years of service was devoted to steppe afforestation, spending quite some time to cope with this difficult task, and thus making forest management in the steppe zone much easier for his successors. Having chosen for afforestation the district with the most adverse climatic and soil conditions - the upper, open, and fruitless steppe laying almost on 17 sazhens higher than the water level in the Kashlagach gully, with heavy soil – von Graff, by experience, has developed the original methods for steppe afforestation and has transferred to his successor L.G.Barck about 150 desyatinas of forests.

In steppe afforestation, the elm family species are dominating comprising more than 50% while ash covers about 35% of the area. Other species are limited in number: maple (*Acer platanoides* L.) – about 5%, oak - 4,3%, white acacia - 3 %, yellow or the Siberian acacia (*Caragana*) - 0,9% and the Tatar maple about 0,8%. Except for forests near a house of forest rangers in the Veliko Anadol site, there is a park in which up to 50 different forest and bush species grow. An orchard and the mulberry nursery are occupying about 40 desyatinas.

Due to the uniqueness of this place and scientific and practical achievements of Veliko Anadol, the first All-Russian Conference (30 June - 4 July, 1948) on steppe afforestation took place here. More than 200 foresters, practitioners, researchers, educators, forest managers and administrators came here to discuss opportunities to create high-grade protective forests for various purposes (Brokgauz and Efron, 1890 – 1916, Mikhovich and Makarenko, 1964, Koldanov, 1992).

The main reasons for forest degradation and deforestation were the elimination of serf responsibility for forest protection, elimination of free serf labor for forest regulation, forest-agronomy and other forest improvement work, and the appearance of large peasant-owned forest plots. Furthermore, landlords who lost free labor to get an earning from their lands and forests began selling their forests. As a result, vast areas were deforested. Forestry of the Russian Empire was in an unsatisfactory condition, and soon, a Resolution on Forest Protection on State Lands was published on June 3, 1869 to improve the situation. However, the results were still far from expectation.

It should be mentioned that the development of capitalism in Russia was accompanied by huge and amplifying destruction of forests. Only in European Russia, within 120 years, about 67 mill. ha of forests were completely destroyed and a forest ratio of the European territory of Russia has decreased from 49.5% in 1696 to 32.5% in 1914. This rate varies from place to place. For example, by provinces the decrease was as follows: in Voronezh, Kursk, Poltava and Kharkov provinces – from 18.4% to 6,8%; in Oryol, Chernigov and Kiev – from 37.3% to 15.3 %; in Liflandskaya, Vilenskaya, Grodno and Kovenskaya provinces – from 34.3% to 19,9%; in the central provinces (Vladimir, Kaluga, Ryazan, etc.) – from 53.2% to 22.2%, etc. Similar processes were going on in the southern provinces of Siberia. The overall deforestation rate in Russia was as follows: in thousand hectares per year, 203 (1696-1741), 233 (1742-1762), 216 (1763-1796), 164 (1797-1861), 902 (1862-1888) and 440 (1888-1914). These data clearly show that the period after the reform of 1861 was the most harmful. These figures can be explained by the change in timber harvesting method: from 1859 onwards almost all heavily forested provinces introduced clear-cut instead of selective harvesting. Especially, it was more disastrous in private forestlands (Tsvetkov, 1957).

Forests of the European part of Russia were the first to be affected by human activities. From 1695 to 1914 they were reduced by one third mainly through cutting and subsequent plowing of private forests for grain cultivation. At the change from the 17th to the 18th Centuries plowed fields in the European part of Russia occupied about 8% while forests still covered half of the total area. With population growth the area of plowed fields, hay fields and pastures increased while the area of forests decreased. Forest cover in the European part in 1696 amounted to 52.7%, in 1725 - to 51.2%, in 1861 - to 42.3%, in 1914 - to 35.2% and in 2000 - to 39.1% of the total land territory.

The modern forest cover of the territory of the European part of Russia is close to the level observed in the previous centuries (49%). However, in 1925 it amounted to only 23%. This means that more than one third of all forests in the European part of Russia are artificially planted while the ratio of deciduous to coniferous trees does not reflect production interests of the economy. According to the state accounting of the forest fund in 1966-2000 forest cover increased from 41 to 45%, including by 0.6% in the last 7 years mainly coniferous species (Pisarenko, 2003).

2.3 Deforestation and Forest Degradation in Siberia and the Russian Far East

Under the Second Decree of 1795 by Empress Ekaterina, the population received a right for the use of timber free of charge and to clearing areas for agricultural purposes (Centenary, 1998). According to that Decree, the Siberian forests of Tobolskaya and Irkutskaya provinces were not subordinated to Admiralty Collegium due to remoteness of those lands and absence of an opportunity of timber transportation by waterways. Because of a combination of extensiveness of these forestlands and a small population of Siberia, it was assumed that the forests "… in those provinces can hardly be exterminated within several centuries. That is why the Decree does not insist on the needs for detailed description of the forests. Instead it is much more important in this region to promote the cultivation of arable lands and clearings for the population, rather than to keep forests. Moreover, it was also not possible to deliver timber to any port..." (Krylov, 1969).

Free and unlimited forest logging allowed by the Decree of 1795 along with severe forest fires in the central and southern forest zone of Siberia have resulted in an exhaustion of massive forests nearby cities and large villages of the Tobolskaya, Tomskaya, Yeniseiskaya and Irkutskaya provinces. By 1822, due to unsystematic logging operations, the well-known Iletsk pine forest was almost completely cut down in the Kurgan district for sale in Permskaya Province. As a result, in 1847 under repeated appeals of forest wardens of the adjacent provinces of Permskaya and Orenburgskaya the senate ruled "to prohibit to peasants of Kurgan district to sell timber both from their own as well as from common state forestlands".

Within a radius of 30-40 kilometers around Omsk, Tomsk and Tyumen' cities deforestation was very severe. In the auditing reports of the special commission of the Ministry of State Properties carried out in 1840, it was remarked that the forests which had been in common use by inhabitants were completely exterminated by deforestation for domestic needs, clearing for agricultural purposes and for manufacturers needs. So, by 1830 there was a lack of accessible forests in all provinces mentioned above. To restrain deforestation of Siberian forestlands, particularly in accessible areas in 1874, forest auditors were appointed, and the stumpage payment was established and inspections began.

For example, the forest auditors V.M.Tihanov and V.A.Engelfeld have prepared a memo based on the results of the inspection of 149 mill. hectares of forests in Western Siberia and a generalization of surveys carried out by the end of 1880. They calculated an average forest cover of 44% of that part of Siberia. V.M.Tihanov has distinguished between the Northern sparsely populated and heavily forested territories of Western Siberia where the forest cover was 71% and southern well populated regions where the major areas of forests were already replaced with arable lands and other agricultural uses and where the forest coverage was only 21%. The southern region was not evenly forested, and the forest ratio varied from 43% in Turinski, Tobolski, Tarski, Tomski, Kannski and Mariinski districts with a total area of 23 mill. hectares to 2% in Akmolinsk and Semipalatinsk provinces[1] with a total area of about 2 mill. hectares. The auditors concluded that before constructing the Trans-Siberian Railway, the attitude towards Western Siberian should be changed and not considered as for "a land of virgin forests". It was found that the forest coverage in many areas of Siberia was lower than that of south-eastern and eastern areas of European Russia (Krylov, 1969).

In 1891, the construction of the Trans-Siberian Railway began. The establishment of this strategically important highway occurred simultaneously from two cities: from Chelyabinsk - to the East and from Vladivostok - to the West. Its construction has caused steady increase of consumption of wood at cross ties, particularly for construction of houses and transport infrastructure. The only commodity not delivered to the construction area was timber, because demand for wood could be satisfied by forests adjacent to the road. The length of the road is 7.500 kilometers. Further, the highway has caused significant inflow of new population to Siberia, basically peasants from densely populated and deforested central and southern regions of European Russia.

Wood demand was high not only for construction of the railroad, but also for house building, heating, and manufacturer's needs. For example, by 1903, more than 12 mill. cross tiers were prepared and stacked. In 1891, at the beginning of the Trans-Siberian highway construction there were 9,600 workers, in 1895-1896, during the peak of the work up to 89,000 people, and in 1904, at the closing stage only 5,300 workers. During the construction of the Amur railway in 1910, more that 20,000 people were involved. Thus, timber consumption has considerably increased causing a high rate of deforestation along the road (Sigachev, 1998).

It should be mentioned that the political situation has changed over the years, and the USSR decided to build another railway because of geo-political concerns (i.e. only in Siberia and the Russian Far East the common border with the People's Republic of China was 4,000 kilometers). An alternative way through Siberia – the Baikal-Amur highway (BAM) was proposed by the Russian Technological Society in 1888. In the early 20th Century there was another discussion (1906) followed by the first prospecting works in 1907-1908 and 1914. The first plan was discussed at Government level in 1924. In 1930, the Far East regional government sent a letter in support of this highway in which it was called Baikal-Amur Highway (BAM).

Actual road construction began after World War Two (1947-1958) and a wide range of work began in 1970 and the railway was completed in the late 1980s. A construction of the second highway involved huge natural, financial and human resources, and also brought new challenges to Siberia due to higher accessibility of its natural resources (BAM History, 2001).

At present time the significant number of deposits of various minerals, and also petroleum and gas are found and mapped in the BAM zone. The extent of the majority of these deposits is authorized and put into the State accounts. Although these amounts are rather insignificant in comparison with all-Russia, stocks of specific deposits play a rather important role for maintaining the Russian industries and in the development of the industry of the eastern regions. Furthermore, the raw material extracted here can be exported to foreign countries (first of all to China, South Korea, Japan). The total value of the total minerals' stocks here is estimated to be 609 billion US dollars (Yatskevich, 2000). This means that overall deforestation of the region will increase dramatically due to regional development as it took place in the southern part of the Russian Far East (Sheingauz, 1998) as described above. With the energy sector development (oil and gas extraction increase), more forestlands were cleared for pipelines and electric power lines.

An important issue of reforestation is restoration of forestland destroyed by direct industrial influences, including coal, ore, peat, oil, and gas exploitation. Total areas of such lands are unknown but are

[1] The last two provinces are now in Kazakhstan.

estimated to be nearly 10 mill. hectares. In the last 2 years, planting and sowing on these lands totaled less than 1,000 hectares in all of Siberia (Siberian Expectations, 2003).

The deforestation and forest rehabilitation efforts could also be seen as a “game of numbers”. For example, the last account of the Russian forestlands within former USSR (as of 01.01.1988) has shown, that in Russia there were 106 mill. hectares of treeless forestlands, including in the Asian part 102.3 mill. hectares, or 96%: the Far East – 78.2 mill. hectares (74%), Eastern Siberia – 19,5 mill. ha (18%) and Western Siberia – 4,6 mill. hectares (4%). Non forest area comprised about 13% of the total forestlands in Russia (State Forest Account, 1988). By 1993, these lands and other treeless areas were considerably reduced due to the change of the status of the openings, which were recognized as low density forestlands and later they were allocated in the State Forest Account under a category of the areas covered with forest as “biological openings” (Bicentenary, 1998).

Another big problem is species composition change. It is a major problem for the European part of Russia due to intensive harvesting, but in Siberia, it occurs even after forest fire. National forest inventory data from 1963 to 1988 show significant trends in cover change over central Siberia, including Krasnoyarsk Krai and Tyva Republic. Over this period, fir stands decreased by 23%, pine stands decreased by 14% (note that, in Russia, the term ‘pine’ refers to 2- and 3-needle pines, primarily Scots pine), and broadleaf areas increased by 60%. Additionally, young and middle-aged stands tripled in area, which is an indication of degradation of mature and over-mature stands. After a disturbance event such as fire or harvest, fir stands are generally replaced by early succession of deciduous species such as birch and aspen. Pine forests occupy poorer sites, where stand replacement due to external factors occurs much more rarely. Development of a second tree layer composed of coniferous species is currently observed in 57% of the total forest area (Pleshikov et al. 1996).

According to data available, today there is practically no site in Siberia which never burned. Shostakovich (1924) described in detail a catastrophic fire of 1915 when precipitation dropped to 30% of long-term normal. In result, the rivers have strongly shoaled; soils and top cover of bogs have dried. The fire started in May in several areas at once and did not stop till August. It has extended over a huge territory - from Sayan mountains to downstream of Yenisei river, and from Ob river to the upstream of Lower Tunguska. In this area, more than half of the forests, a huge number of animals and almost all insects were destroyed completely. There were cases of people’s deaths, too. The smoke has spread over hundreds of kilometers. Steamship movement has stopped on the large rivers; many areas appeared to have been cut off from any supplies. Animals which did not eat the bitter grass become impregnated with smoke causing cattle mortality. Hot air and smoke have driven clouds far outside the fire areas, excepting steam condensation in general. After that many drought years with large-scale fires have followed, especially in the years of 1925, 1928, 1947, 1962, 1971 (Parmuzin, 1985).

In 1915, only in central part of Siberia, wild forest fires have caught more than 15 mill. hectares and destroyed the property of many people. During 1923-1925 forest fires burnt at average 1.4 thousand hectares out of 1,000 thousand hectares of the USSR forestlands (Forestry in the USSR, 1967). Assuming that the total forest area was equal to that of today, we could come to the conclusion that the forest area burnt is close to 1.5 mill. hectares as recorded by the forest services.

As a consequence of fire, huge areas of forests are exposed to the influence of biotic factors such as pest outbreaks and fungi. The officially reported total area of forests affected by insects and diseases during the last 15 years on average ranges between about 5 mill. hectares to above 10 mill. hectares. The opinion of Russian scientists and forest professionals is that the damage caused by insects and diseases is of the same magnitude than that caused by fire. Acceleration of the impacts of pests and diseases on forest ecosystems has been observed over the last decades. The major reasons of this are increasing anthropogenic pressure on forests and ongoing climatic change. Reliability and completeness of data on biotic disturbances are similar to those discussed for fire. Particularly incomplete are data for remote and sparsely populated regions (Forestry and Forests, 2007).

According to I.V.Vasiliev (1905), outbreak of Siberian silkworm *Dendrolimus superans sibiricus Tschetv.* affected big areas of Siberian pine (Siberian cedar) in Irkutsk province that caused a dramatic decline in hunting and nut collecting being harmful to the whole economy of this territory (Forestry in the USSR, 1967). In 1952-1957, this insect destroyed 4 mill. hectares of dark taiga forests, mainly – true fir forests. According to Yu.I.Gninenko (2003), in Siberian forests during the 20th Century the area under destructive influence of Siberian silkworm with subsequent development of black fir capricorn beetle centers and occurrence of forest fires is estimated at about 20 mill. hectares. Partly, this territory till now is still not regenerated placing significant harm to the economy and environment of the country. In the south of Siberia, there is a deterioration of forest health, caused by the influence of root pathogens (*Armillaria mellea sensulato and Heterobasidion annosum sensu stricto*). For example, in the Minusisnsk area of Krasnoyarsk Krai, 955 hectares of root disease centers were recently detected (Pavlov, 2007). In 2000-2001, the Siberian silkworm infested areas of about 10 mill. hectares, mostly in the zone of central taiga in territories, where such wide distribution of this insect has never been observed before (Forestry and Forests, 2007).

The most powerful sources of atmospheric emissions and toxic polluting substances are the enterprises of nonferrous metallurgy and power generation. In this case, especially dangerous to the environment are plants of aluminium production; for example, there are four factories in the Angara river basin, and a construction of one more is considered (Pavlov, 2007).

In general, forest resources in Siberia can be characterized by the following major features:

- *Low Productivity of Forests.* About 50% of the region is occupied by stands of low productivity with growing stock up to 100 cu m per ha.
- *Fire Losses.* Annually, nearly 500,000 ha of forested areas are lost due to severe wildfires.
- *Harvesting Pattern.* Over-cutting of timber has occurred along the main railroad transportation routes and close to manufacturing centers.
- *Harvesting Areas.* There has been a significant increase in the rate of harvest in remote regions.
- *Timber Utilization.* The high grading of timber resources is widespread. There are serious losses of wood during transport from harvest sites to consumers due to improper transportation methods, old machinery, and inefficient rafting.
- *Tree Species Composition Change.* Clear-cutting methods combined with fire losses have resulted in a change of up to 50% of these areas from conifers to soft deciduous species.
- *Forest Health.* Large areas show a decrease in forest health due to attacks by insects and diseases, unsound final harvesting methods, pollution, and other factors. The area of non-regenerated cuts, burns, and dead stands is nearly 16 mill. hectares in East Siberia alone.
- *Silviculture.* Commonly used silviculture methods are not adequate, resulting in an inefficient forest renewal program.
- *General Forest Resources Dynamics.* The forest resources are deteriorating slowly but significantly in Siberia. Generally, the practice of forestry in Siberia cannot be considered sustainable. The key issue in Siberian forestry is to establish a sustainable form of management that develops forest resources from ecological, economic, and social points of view.

Although opportunities do exist in the Siberian forest sector there are a number of areas that can be focused on now to promote sustainable management (Forestry in the USSR, 1967, Sheingauz, 1998, Siberian expectations, 2003, Russian Forests, 2005, Russian Forests and Forestry, 2007, Pavlov, 2007).

2.4 Trends in Rehabilitation of Degraded Forests

The first plantings of forests in the Urals were carried out in 1818 nearby the Kamensky factory, and during 1818-1832, pine trees were sowed here on an area of 57 hectares. In 1832, in the district of the Botkin industrial unit, within 7 years (1832-1839) an area of 290 hectares was successfully restocked based on experiences made with oak and pine trees sowing. In 1829, the training of young people (mainly from serfs) in tree planting began in Yekaterinburg. In about the same period, Shultz, the chief forester of the Urals mountain factories, has introduced the seeder designed by him for forest sowing practice. Systematic forest management planning in the Urals began in 1832, apparently earlier than in other places of Russia (Melekhov, 1957).

The efforts to better management of forests including reforestation and afforestation began to pay off also in other regions, and in Russia as a whole. For example, the accounts of the Forest Department of 1845, 1847 and 1853 show the growth of the area of reforested areas respectively: 8,732 hectares, 17,420 and 38,894 hectares (Centenary, 1898).

Reforestation in openings such as clear cuts and glades was mainly done to support natural regeneration. In 1849, it was prescribed to establish a tree nursery at each state forest. The nursery should cover the area of 2 - 4 hectares and had to be fenced to protect against cattle and wildlife. If the clear cuts are not regenerated within five years, the cutting operations should be terminated until seedling appeared naturally.

Later on, in 1856, temporal tree nurseries have received preference against permanent ones. Forest strips were established to protect arable lands from drought and winds and strips to collect winter precipitations (snow) and prolong moisture in the soils (Pisarenko, Red'ko and Merzlenko, 1992).

"The Directive for Forest Cultivation" was adopted in 1845 to help people in calculating the cost of artificial forest regeneration, and in 1854 – "The Statute on Seed Collection and Procedure of Requesting and Sending Out" and "The Directive on Tree Seed Collection". A positive role was also played by the Senate Decree of March 28, 1850 on "State Peasants Participation in Forest Reproduction". From 1850, reforestation and afforestation received considerable attention. The most famous forest plantations in Russia were established by K. F. Tjurmer in Porechye and the First Pokrovskoye forest area in Vladimir province. An acceptance of the Law "On Forest Planting Assurance" (1899) has resulted in an increase in forest sowing and planting by ten times.

The basic questions were solved after 1859 when all state forestlands were brought under the management of the State Forest Department. This was characterized by centralization of management, prestige for those in the service and entering into such institutes was considered honorable and showed dedication to a duty. The fundamental triune purposes of forestry were determined:

- to protect forests from destruction;
- to take the greatest income out of them; *and*
- to increase forestland in territories requiring forest vegetation.

These goals remained constant during more than 150 years; they received different priorities depending only upon the political and economic situation in the country.

Within the set of activities related to artificial afforestation forest cultivation comes increasingly to the forefront. Cultivation of forest plants should be based on ecological and forestry principles bearing in mind that the combination of forest restoration targets should be regarded as a natural system dynamic in space and time which changes both in a geographic aspect and under the influence of economic activities. It follows that all forestry activities should be focused on the provision of normal functioning of forest plants and increase in their productivity.

Forest restoration represents a managed process and foresters face the task of choosing the best option from among many available ones, implementation of which will ensure the best result at a minimum cost. It is particularly urgent today when the bulk of logging activities has been transferred to the taiga zone where due to natural conditions and diversity of forest restoration methods the choice of the best option represents a rather difficult challenge.

The history of forest cultivation development serves as an example of lengthy search for the best methods and ways of artificial forest cultivation. Forestry has undergone a long way of development, at different stages of which the efforts of scientists and professionals have been focused both on the principles of nature imitation, search for the most efficient measures facilitating natural restoration of the main forest-forming varieties, and on the elaboration of methods of artificial cultivation of forest plants on the basis of local and introduced species (Pisarenko, 2003).

Overall achievement of forest restoration works (Table 5) was small in the beginning. Only 899 thousand hectares of forests were sown and planted in state forestlands within 74 years from 1844 till 1917. In the next 73 years of the Soviet period 44,550 thousand hectares were established and in the new Russia era 4,866 thousand hectares in 1991-2006 (Forestry in the USSR, 1967; Pisarenko, Red'ko and Merzlenko, 1992, Basic parameters, 2006).

The trends show that in the last quarter of the 20th Century forest renewal in the Russian Federation was accomplished mainly by assisted natural regeneration. Over the past 90 years, sowing and planting were carried out annually on significant areas. Even during World War Two, new forests were planted on an area of 165 thousand hectares.

Russian forestry has been developed according to a slogan of Prof. Georgy Morozov "harvesting and regeneration are synonyms." The idea is to use natural mechanisms in seed production and forest self-regeneration (Morozov, 1994). According to this concept, felling operations in Russia comprise a wide range of techniques including clear cutting, gradual cutting, two-stage, shelterwood, group, even-gradual, selective cutting, selection felling, group selection and others. These could be grouped into three major categories, namely clear, gradual and selective cutting. The choice of the harvesting method is determined by the characteristics of forest stands, target designation of forestland and economic feasibility. Major harvesting technique is clear cutting. Introduction of gradual and selective harvesting methods is also of interest, but the share of such felling is currently not high.

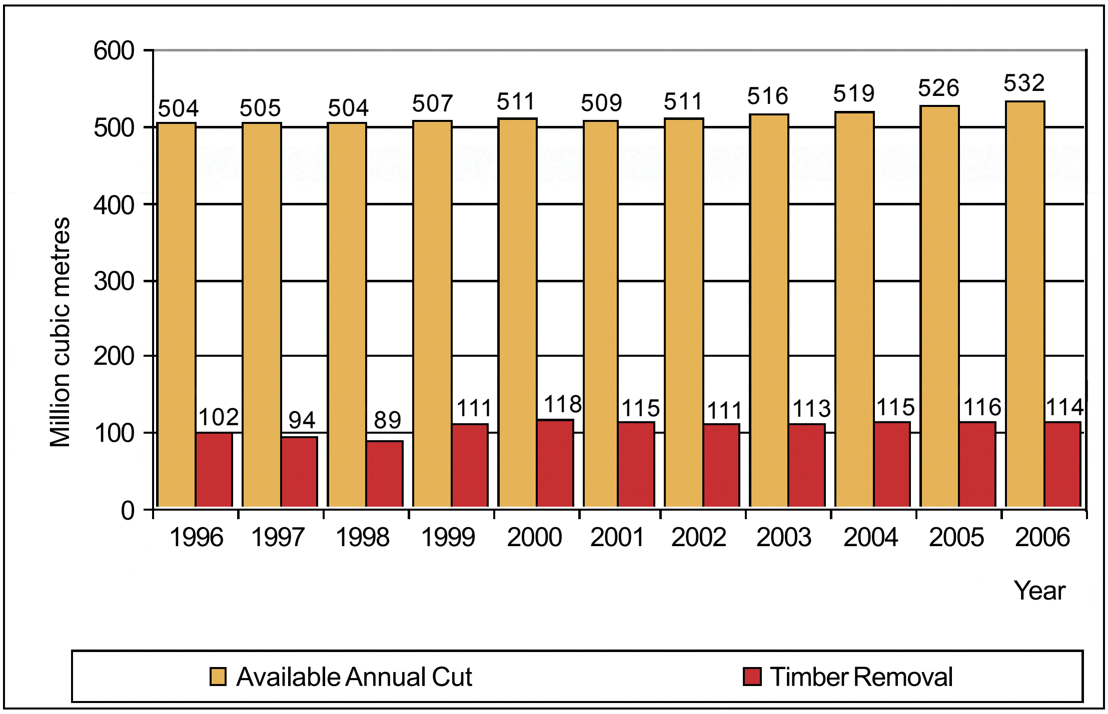
Gradual and selective cuttings are used mostly in protective forests. Under these harvesting systems about 40% of the area is affected by cutting with about 20% of total timber removed. In 2006, the area of commercial wood harvesting in the Russian Federation amounted to 795.2 thousand hectares which is 3.4 thousand hectares more than in 2005. The total volume of timber harvested was 127.6 mill. cu m, 114.1 mill. cu m have been harvested on lands under supervision of the Russian Federal Forestry Agency. The available annual cut (AAC) established for these forests is 531.7 mill. cu m, that is 5.2 mill. cu m more than in 2005 (Figure 8). The last figure shows the continuous accumulation of timber in mature and over mature forest stands, mainly of hardwood species.

Table 5: ***Forest Renewal in Russia (1844-2006)***

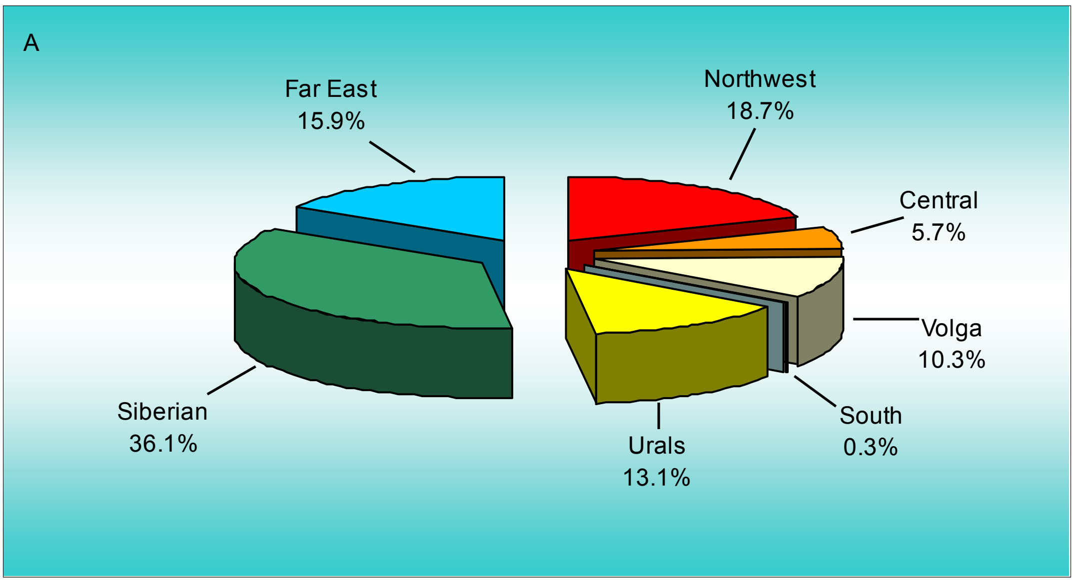
Years	Sowing and planting	Assistance to natural regenera-tion	Total	Annual Average		
				Sowing and planting	Assistance to natural regeneration	Total
1844 - 1917	899	310	1,209	12	4	16
Sub-total	***899***	310	1,209	12	4	16
1918 - 1927	412	25	437	41	3	44
1928 - 1932	534	25	559	107	5	112
1933 - 1937	684	47	731	137	9	146
1938 - 1941	964	90	1,054	241	22	263
1942 - 1945	165	80	245	41	20	61
1946 - 1950	1,715	1,011	2,726	343	202	545
1951 - 1955	2,817	2,732	5,549	563	546	1,109
1956 - 1960	3,196	3,395	6,591	639	679	1,318
1961 - 1965	5,736	3,660	9,396	1,147	732	1,879
1966 - 1970	6,440	4,760	11,200	1,238	832	2,070
1971 - 1975	6,800	5,385	11,685	1,260	1,073	2,337
1976 - 1980	5,244	5,495	10,739	1,049	1,099	2,148
1981 - 1985	4,941	5,824	10,765	988	1,165	2,153
1986 - 1990	4,902	6,084	10,986	980	1,217	2,197
Sub-total	**44,550**	**38,613**	**82,663**	**610**	**529**	**1,132**
1991 - 1995	2,154	5,349	7,503	431	1,070	1,501
1996 - 2000	1,348	3,801	5,149	270	760	1,030
2001 - 2005	1,169	3,121	4,290	234	624	858
2006 - 2010	195	682	877	195	682	877
Sub-total	**4,866**	**12,953**	**17,819**	**304**	**810**	**1,114**
Total	**50,315**	**38,613**	**101,691**	**311**	**320**	**628**

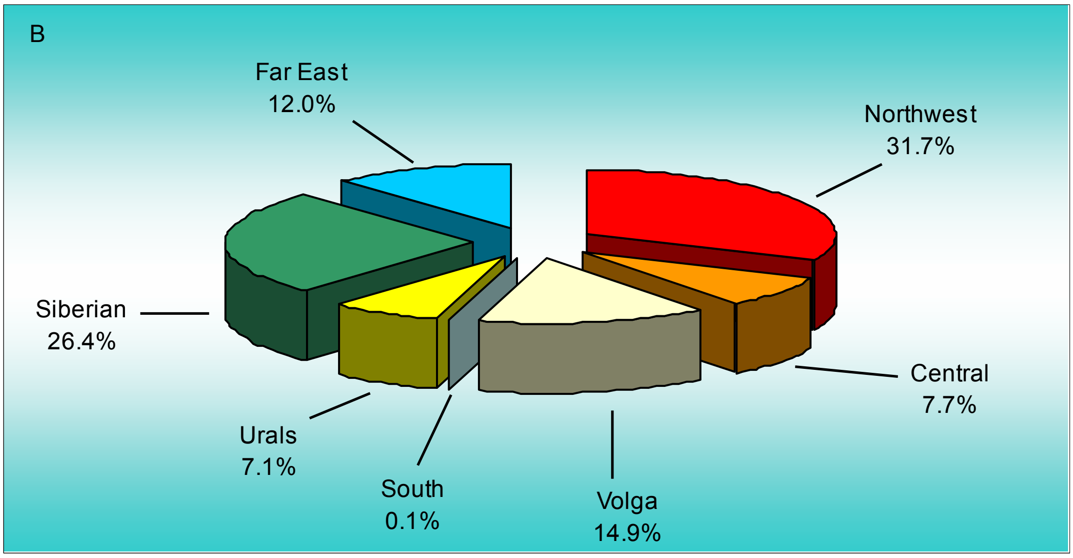
More than a half (54%) of the AAC is harvested in the Asian part of the country, mainly on the Siberian and Far East federal districts (Figure 9A). The volume of timber harvested is more equally distributed between the Asian (49.4 %) and Europe-Ural (50.6%) parts of the country. A major volume of timber (58%) is harvested in the Northwest and Siberian federal districts (Figure 9B). It shows more intensive development of the forest industry in these regions having more wood processing capacities and being close to commodity markets.

Figure 8: ***Annual Allowable Cut and Actual Harvest Volumes in the Russian Federation***



Figures 9A and 9B: ***Distribution of Timber Harvest by Region***



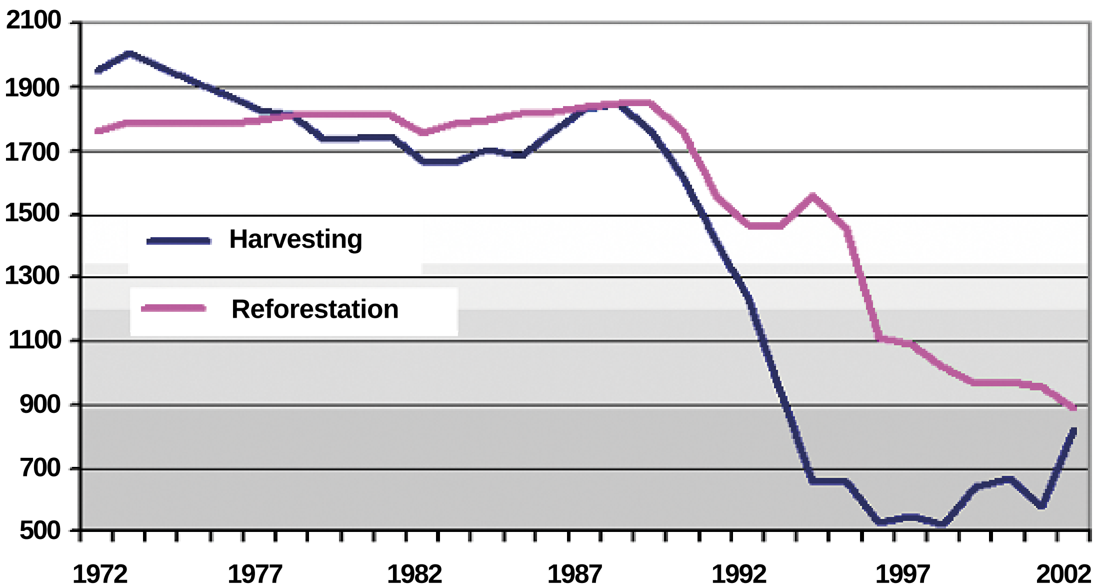


Reproduction of forests as a process of reconstruction of forest stands with all its essential properties is one of the main tasks of Russia's forestry. The basic component of forest reproduction is proper forest regeneration on cuttings, areas of burnt forests and lost stands, and a reduction of currently deforested lands with forest vegetation. These tasks have been given priority under the State Programs on Reforestation within the period 1980-2000.

The harvesting and forest restoration volumes are closely interlinked (Figure 10). The trends show that the reforestation rate is much higher since the1990s, and this is true over the last few years as well. In 2006, as well as in previous five years, the annual area of forest renewal exceeds the areas of clear cuts. To note, in 2006 clear cuts were carried out in the area of 755,080 hectares. The latest forest renewal factor of 1.16, determined as ratio of the area of forest renewal to the area of clear cuts, shows that the extent of forest rehabilitation exceeds the cutting area, although both have significantly declined.

Current primary goals on forest renewal are outlined in the sub-program "Forest" of the federal target program "Ecology and Natural Resources of Russia (2002-2010)", authorized by the decision of the

Figure 10: ***Annual Harvesting and Reforestation Area***



Government of the Russian Federation (07.12.2001, No. 860). For this period it is necessary to carry out forest renewal operations in Russia on the area of 6.9 mill. hectares and to provide an input of young growths into a category of valuable wood plantings on the area of 9.5 mill. hectares.

In 2006, land without forests in Russia occupies 102.7 mill. hectares of which 32.2 mill. hectares belong to the land fund for forest renewal. Because of forest fires in 2006 in Central, Northwest, Southern, Volga and especially in Siberian federal districts, there was a significant increase of the areas of burnt forest to be reforested. Seventy seven per cent of the fund for forest renewal is spent on burnt areas located mainly in the Asian part of Russia; another 10% are openings after clearcut, 9% are low density forests and 4% belong to natural openings.

Forest ground vegetation and soils are mostly damaged during timber felling operations, especially in mountain areas. For example, during clear cutting, soil damage occurs at some 80-85% of the sites, while in gradual harvesting at final cut the share is 35-75%, and in selective harvesting 20% of the area under felling.

2.5 Rehabilitation Techniques and Planted Species

Forests rehabilitation is a complicated combination of knowledge of many disciplines. From the economic point of view, silviculture is central to rehabilitation, because the main goal of silviculture is to timely and properly harvest and restore economically valuable stands in the felling sites, burnt areas and declining forests, as well as to decrease forest land area that is not covered with forest vegetation.

From this point of view, the main area of activity of forest management units is in the reproduction of forest resources. Timely restoration of valuable forests on cutting and burnt areas, reduction of the available forestlands, which are not covered with forest vegetation, planting of protective forest strips on agricultural lands is ensured by a wide range of activities. Thus, first and foremost, it includes forest planting and sowing, assistance of natural regeneration, agro-technical and treatment of forest planting stocks and natural young forests (Pisarenko, 2003).

Forest rehabilitation techniques are dealing with appropriate methods of forest re-establishment, either by natural or artificial means or by a mixture of both.

Natural forest regeneration is a basic approach, and if not very successful it requires some assistance from a forester. A success is determined by a forester, and can be mainly described in terms of desired tree species (mainly coniferous), an appropriate number of individuals per hectare (usually about 3,000), health conditions and reliability of under-storey and young growth left in clearcuts or having survived after fire, and seed production of mature trees.

On the sites, the means of assistance to natural forest renewal could be done by various methods: preservation of young growth (improvement of harvesting method and preference of selective felling), retaining enough seed trees, tree groups and strips, a mineralization (scarification) of soil, prescribed burning, and also additional tree sowing and supplementary planting of coniferous species on cutting areas with insufficient amount of natural young growth.

In all types of natural and artificial forest renewal, be it preliminary, accompanying or subsequent, time matters most; e.g. time required for establishment of young trees under canopy from seeds or as planted young trees. This is also true for areas destroyed by forest fires.

In the case of clear cuttings accompanied by preliminary (advance) regeneration the following rules are applied in most places in Russia:

- the soil properties must be maintained;
- any negative impacts on the soil must be eliminated;
- the under-storey vegetation must be retained;
- forest areas of more than 1 hectare with valuable advance growth must be selected;
- forest plots requiring supplementary regeneration material must be identified;
- young trees of cedar (*Siberian pine*) must be retained as well as young oak and beech in the mountain forests in connection with all kinds of cuttings regardless of their volume and location.

A similar approach is applied when carrying out clear cutting followed by subsequent artificial regeneration:

- the soil properties must be maintained;
- any negative impacts on the soil must be eliminated;
- favorable conditions for natural and artificial regeneration must be created;
- seed trees must be retained as well as a viable under-storey of valuable trees;
- logging waste must not cover more than 15% of the cutting area.

Artificial forest restoration (reforestation) is a more complicated method. It passes through many stages: seed treatment (collection, storage, seed orchards), seedling (1-2 years old plants) and sapling (3-5 years old) growing (greenhouses or outdoor, bare roots or containers, etc.) in tree nurseries (soil preparation and treatment, mechanization, watering and fertilization, etc.), transplanting to the site (desired scheme, mixture, species composition, etc.), and further treatment (fire prevention, thinning, pest control, etc.) that become very complicated and costly in many instances. Pest control is a necessary means at every stage of artificial forest restoration, from seed stage to the mature stand.

The majority of harvested stands in Russia is suitable for natural regeneration by conifers. However, some areas are artificially reforested. As a general rule the ratios between natural regeneration and planting trees are as follows (Pisarenko, Red'ko and Merzlenko, 1992):

- northern and central taiga - 70:30
- southern taiga - 50:50
- mixed forests - 30:70
- forest steppe - 5:95
- steppe - 0:100

Due to a difference in intensity of forestry and forest typology features this ratio in concrete forest areas can be different. For example, in Western Siberia and mountain regions, this ratio is:

- northern taiga - 90:10
- central taiga - 80:20
- southern taiga - 65:35
- forest steppe - 25:75
- upper and middle elevation mountain forests - 85:15
- lower mountain forests - 65:35

It also depends on the existence of young tree generations under the canopy. The following figures demonstrate the minimum number of viable young trees that allows to leave clear cuts for natural forest renewal (Table 6).

Furthermore, the presence of young trees on harvesting sites and on clear cuts (after felling) gives foresters an opportunity to save resources for artificial forest restoration depending on site class, forest type, and tree species dominance. An example for Eastern Siberia is shown in Table 7 for two tree species. Similar regulations are available for most of the dominant forest species in Siberia.

Now the basic technology of assistance to natural forest renewal is the preservation of viable young growth and small-sized trees of coniferous species during forest harvesting. New machinery is employed and allows for retaining up to 60-80% of the young growth and small-sized trees during harvesting. This pool of trees along with subsequent seed and vegetative renewal of forests results in productive coniferous and mixed stands at the age of maturity. On deforestation areas with insufficient quantity of young growth, artificial or combined forest restoration techniques are in practice.

In Siberia artificial forest restoration is based on silvicultural prescriptions and the use of proven technologies with a high level of mechanization of forestry operations for clear felling, soil preparation, tree planting and subsequent silviculture treatment.

Artificial forest regeneration is based on the following methodology (Figure 11) and is implemented in Russia. Modeling of the plantation is the most important phase, because at this stage the following important parameters should be estimated: (a) growing conditions such as geography of the site, climate, soil, etc., (b) species composition and their biology, ecology, and growth suitable for the growing conditions and meeting the goal; (c) allocation of planting sites and technology of establishment, because the mode of establishment itself is a reflection of the modeling step. Establishment is mostly a technical

Table 6: ***Minimum Natural Forest Renewal Standard of the Main Tree Species on Clear Cuts and Fire Areas in Western Siberia Expressed as Number per Hectare o Viable Young Growth (Height of 0,5-1,5*** **m, in '000)**

Tree Species	Groups of forest types	Northern and Middle Taiga	Southern Taiga	Forest Steppe and Steppe	Lower Mountain Forests	Middle Elevation Mountain Forests
Pine, Larch	Lichens and upper land	2,5	2,5	1,5	-	-
	Green moss	4,0	4,5	2,0	4,0	3,0
	Bilberry and bog-moss	3,5	3,0	2,0	3,0	2,5
Spruce, Fir	Green moss, bilberry and bog-moss	2,5	2,0	-	2,5	3,0
	Grass and grass-marshland	2,0	1,5	-	1,5	2,0
Siberian Cedar (Siberian Pine)	Green moss, bilberry and bog-moss	1,5	1,0	-	1,5	2,0
	Grass and grass-marshland	1,0	1,0	- -	1,0	1,5
Birch from Seed Origin	Green moss	3,0	5,0	2,5	4,0	3,0
	Bilberry, bog-moss and grass-marshland	5,0	7,0	3,0	6,0	5,0

stage, but requires accuracy and care merging agro-technical means and ecology of the future planting especially taking into consideration the basic method of sowing or planting. The growing phases with silviculture treatment are the final stage of the site's artificial regeneration (Pisarenko, Red'ko and Merzlenko, 1992).

Major new forests planted and re-planted in Russia are conifers (basically pine and spruce, but also larch, true fir) – about 79-80%, deciduous species (oak, birch, elm, ash, poplar) – 18-19% and bushes – about 0.5-1% of total forests planted. The choice depends on the place, geography, climate, soils, aim of planting, economical factors including amount of forests in the region (sparsely forested or heavily forested), rotation age, desired size of trees at harvesting, and other factors (Russian Forests, 2005, Russian Forests and Forestry, 2007).

Within the period 1971-1979 the following tree species were used in major planted forest: 3,149 thousand hectares of pine plantings, 1,643 thousand ha of spruce, 142 thousand ha of oak, 92 thousand ha of larch, 31 thousand of poplar and 22 thousand ha of beech. Alongside, in 1966-1980 more than 302 thousand hectares were planted with Siberian pine (Bicentenary, 1998).

From 1966 to 2000 the share of pine in the composition of plants decreased from 62 to 34%. Oak trees were cultivated predominantly in the European-Urals region and their share in this period decreased from 3.4 to 2.3% from the total. In the Asian part of Russia forests are cultivated mainly in the regions of commercial logging. The major share of these forests can be found in Altaisky krai – 6%, Omsk province-3.5%, Sakhalin province – 3%. In the last 20 years the volumes of cedar cultivation in the Asian part of Russia increased from 11 to 23%. As a result the composition of forest plants transferred into forest-

Table 7: ***Forest Renewal Activities in Eastern Siberia Depending on Tree Species, Groups of Forest Types and Growing Conditions: Number of Young Growth on Harvesting Sites (upper line) and Clear Cuts (lower line), in '000 per Hectare (Excerpt)***

Tree Species	Major Groups of Forest Types	Forest Renewal			
		No need	Assistance to natural regeneration	Partial Reforestation	Total Reforestation
Pine, Larch	Lichens, stone, dad cover, steppe like and other, similar, forest types. Underdeveloped podzol soils. Grey forest, dry sandy, sandy loam and light loamy soils	> 6.0 / > 3.9	5.0 - 6.0 / 3.2 - 3.9	4.0 - 4.9 / 2.6 - 3.1	< 4.0 / 2.6
	Cowberry, rhododendron, grass and similar forest types. Small gravel sandy, light loamy moisturized soils	> 5.0 / > 3.3	4.0 - 5.0 / 2.6 - 3.2	3.0 - 3.9 / 2.0 - 2.5	< 3.0 / < 2.0
	Green moss, shamrock, bilberry, grass and similar forest types. Turf-podzol and turf-forest sandy, loamy humid soils	> 4.5 / > 2.9	3.5 - 4.5 / 2.3 - 2.9	2.5 - 3.4 / 1.6 - 2.2	< 2.5 / < 1.6
Spruce, True Fir	Green moss, shamrock, fern, bilberry, grass and similar forest types. Podzol and turf-podzol sandy and loamy soils	> 4.0 / > 2.6	2.5 - 3.9 / 1.6 - 2.5	2.0 - 2.4 / 1.3 - 1.5	< 2.0 / < 1.3

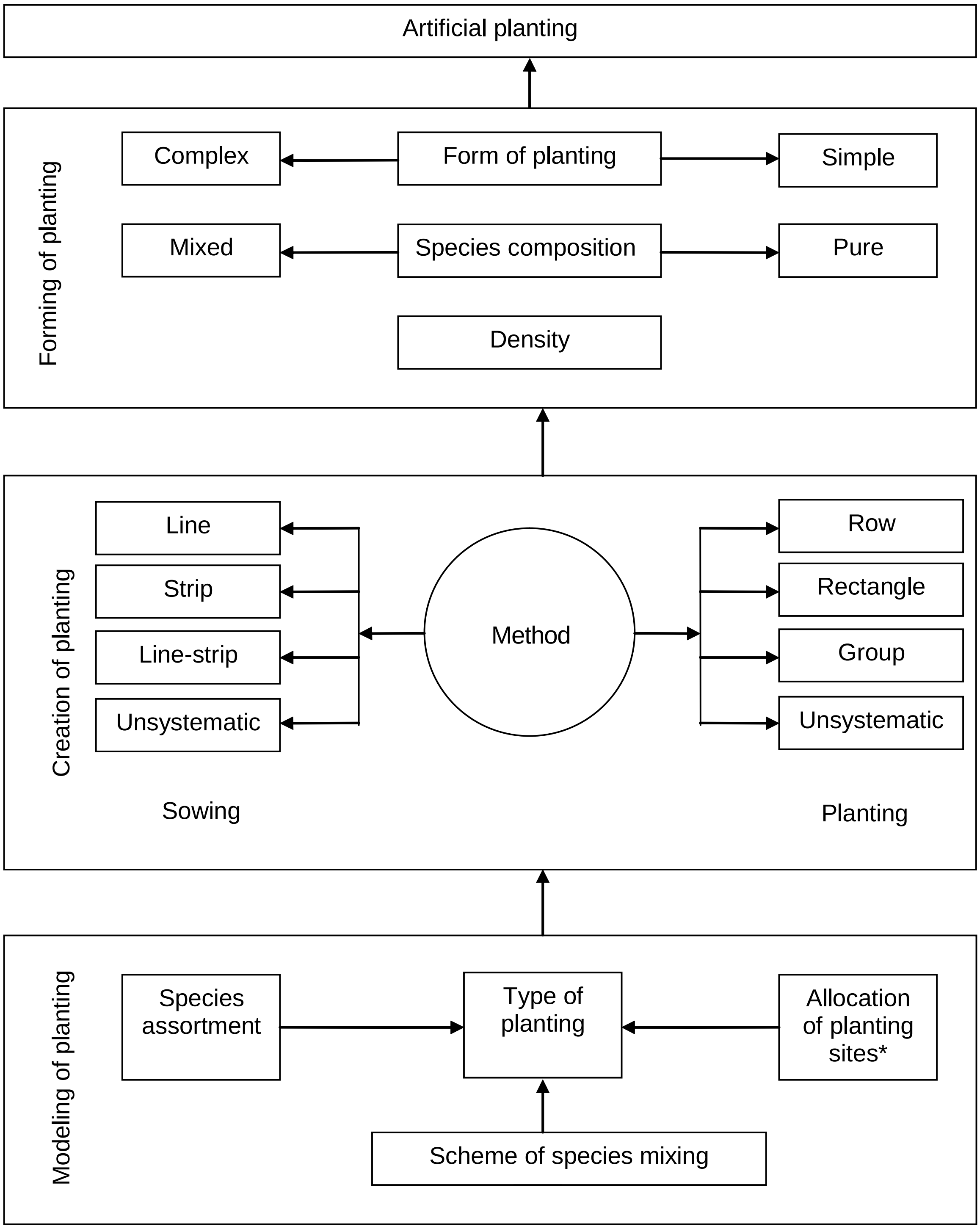
covered area has markedly changed in favor of spruce and cedar to the detriment of pine and oak, although larch is also considered (Pisarenko, 2003).

Forest rehabilitation depends on seed available for forest regeneration and their quality. During the last decade about 1000 tons of seed of more than 100 species of trees and bush varieties have been stored, including nearly 100 tons of small coniferous varieties. Methodological guidance of harvest forecasting, seed collection, treatment and storage and organization of forest seed control is performed by the State Federal Enterprise “Centrlessem” and its 34 zonal forest plant seed-growing affiliates. Within the system of forestry farms there are 7 seed selection centers and 34 functioning forest seed-growing stations.

The permanent forest seed-growing network consists of 44 thousand quality trees, 18 thousand hectares of quality stands and more than 4 thousand permanent forest seed-growing sites. For the preservation of valuable genetic resources 235 thousand hectares of forest genetic reservations have been designated and about 500 hectares of archived clones and 1000 hectares of pilot valuable varieties have been established. From the sites of the permanent forest seed-growing base 100-150 tons of seeds have been collected which amounts to 13-15% of the entire seed pool.

Permanent and temporary nurseries with a total area of about 23 thousand hectares represent the forest nursery system. The number of permanent nurseries amounts to 1.3 thousand stations with a total area of 21 thousand hectares, including 230 irrigated stations with the area of 4.4 thousand hectares. Besides,

Figure 11: ***Metholdolgy of Artificial Regeneration***



* Number seedling or sampling per hectare and future configuration (line, rectangle, etc.)

there are 979 greenhouses with a total area of 63 hectares. On this basis 1.4-1.6 billion seedlings and saplings are annually cultivated for afforestation and protective forest cultivation activities but it could be cultivated much more. The work of the nursery system is supported by the agro-chemical service, which includes 48 soil-chemical laboratories with a total staff of 150 professionals (Pisarenko, 2003, Russian Forests, 2005).

Case 1. Larch Plantations in the Siberian Forest-Steppe

The researchers of the Siberian Technological Institute proposed to plant larch forests on clearcut areas introducing up to 20-25% of Scotch pine or Siberian pine (cedar) trees in mountain-grass and mountain-cowberry forest types and 20-25% of birch of pine trees in mountain-steppe forest type and some shrubs like *Caragana*, *Lonicera, Spirea* and mountain ash to improve soil fertility. They recommended the following mixture of species:

1) Larch – Larch – Larch – Larch – Larch
2) Larch – Larch – Larch – Larch – Larch – Birch
3) Larch – Larch – Larch – Larch – Larch – shrub – Siberian pine – shrub – Larch

Tree and shrub species are planted in a plough furrow in a distance of 2-5 meters from each other at a small amount of stubs on cutting area, and 5-10 meters if the amount of stubs is more than 500 pieces per hectare. In the second case, saplings are planted in two lines on edges of plough furrow in a distance of 2 meters from each other.

Dense larch plantations should be treated within groups of trees. For example, in the Sonsky forest management unit of Krasnoyarsk Krai, thinning was done in ten years-old plantations of Siberian larch. After three years there was an increase of growth in height by 15% and in diameter by 60% compared with the groups without thinning. This shows that thinning in dense plantations can enhance the growth in timber volume (Pisarenko, Red'ko, Merzlenko, 1992).

In 2006, forest management units of the Russian Federation were supplied with seeds. As of 01.01.2006 the surplus of seeds in forestry units comprised 333,951 kg; of which: fir-trees – 50,762, pine – 60,024, cedar (Siberian pine) – 130,544, larches – 10,283, and oak – 53,891 kilograms. 66.7% of the seeds were rated as first quality class while 29.8% were of second class. High priority was given to the creation of reserve stocks of seeds: 347.9 tons of seeds of more than 100 woody and brush species, including coniferous (pine, fir-tree, larch) – 55.7 tons were collected. In tree nurseries 1.28 billion seedlings of standard sowing material have been grown.

In 2006, forest regeneration occurred on an area of 877,300 hectares, including tree planting on an area of 194,500 hectares, and through the assistance to natural forest renewal on 648,600 hectares, which is now the principle approach of forest rehabilitation in the Russian Federation. As a result of natural renewal of birch and aspen on the areas with planted coniferous trees, mixed stands are established. This is considered most desirable both from the point of view of achieving the economic objectives and environmental goals, particularly the conservation of biological diversity.

2.6 State Protective Forest strips (Shelterbelts)

Protective afforestation represents a complex approach to plant, grow and use forests to protect agricultural lands, soil, roads, channels and settlements from unfavorable natural phenomena such as droughts, storms, water erosion, dust storm, snow drift, floods and damaging mechanical impacts.

The problem of forest cultivation in areas where forests had been removed a long time ago, like forest-steppe and steppe, and with its help to prevent agricultural crops from fatal influence of droughts, dry winds, dusty storms and other adverse natural phenomena, as well as to improve hydrological and climatic conditions of steppe and forest-steppe areas of Russia have very much occupied the minds of many scientists for a long time.

Although outstanding Russian scientists like V. V. Dokuchaev, P. A. Kostychev, K. A. Timirjazev, G.N.Vysotsky, and later on V.R.Williams and many others highlighted forest plantations in the general system of actions for combating natural disturbance/disasters, the imperial government did not pay much attention to protective afforestation, and private ownership did not allow carrying out this work at the necessary level. Only after World War Two, systematic afforestation in steppe and forest-steppe areas was started on an industrial scale.

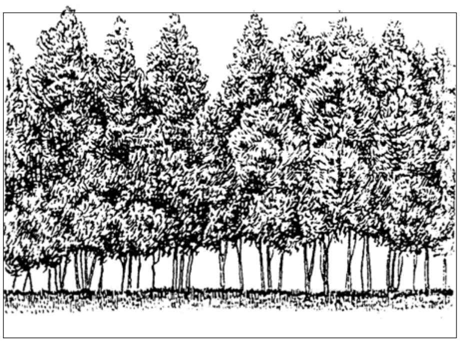
Box 2. Design of Ameliorative Forest Strips (Shelterbelts)

Forest amelioration plantations for water and wind erosion control on arable lands, mountain slopes and other areas, along railways etc. play an important role. Forest melioration plantations can be shaped as belts, separated stands, blocks, massive tracts. Ultimate effect is reached where plantations form an interconnected system of shelterbelts of explicit structures.

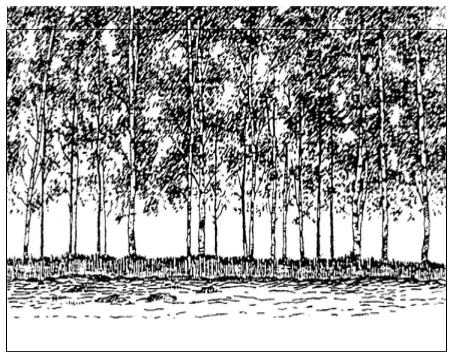
Dense structure shelterbelts have no gaps along the entire length. As a rule they consist of dominant, associated species and brushes (See A). Open structure shelterbelts have evenly spaced gaps that range between 15 and 35% of the entire shelterbelt length (B). Sparse structure shelterbelts have big gaps over 60% between trees in the lower section of the longitudinal profile, while there are no gaps in the upper section of the shelterbelt or in crowns (C). Open-sparse shelterbelts have gaps over 60% in the lower section of their longitudinal profile and 15-35% gaps evenly spaced in the upper crown section (D).

A. Dense structure shelterbelt

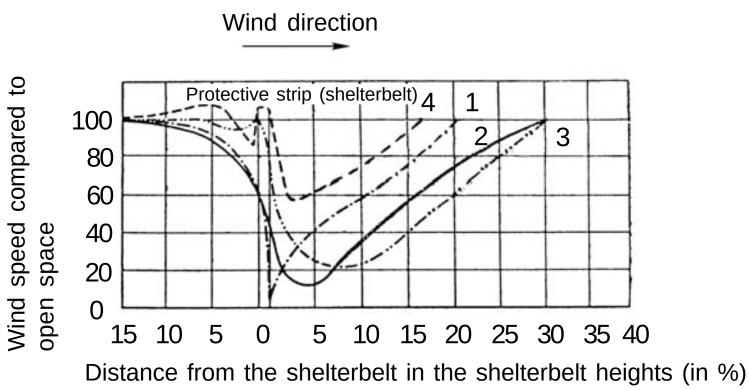
B. Open structure shelterbelt



C. Sparse structure shelterbelt



D. Open-sparse shelterbelt



E. An effect of various structures of shelterbelts on wind speed:
1 – dense; 2 – open; 3 – sparse; 4 – open-sparse

Box 2. Design of Ameliorative Forest Strips (Shelterbelts) - continued

Differently structured shelterbelts affect wind speed in different ways (See E). Ten percent of wind speed reduction is considered efficient. Under specific conditions, the range of the shelterbelt effect on wind speed, wind flow movement and other microclimate components may vary considerably depending on many factors.

Positive effects of shelterbelts established on agricultural lands on microclimate, abiotic factors and physiological processes in plants result in agricultural crop yield growth in rainy and dry years. In wind-penetrable shelterbelt systems wind speed drops by 40-50%, water evaporation in dry days – by 20-30% and air moisture compared to open steppe increases by 8-10%. Snow cover on crop fields between shelterbelts is more sufficient providing better conditions for agricultural crops wintering and water build-up in soils in spring. Less frozen soil of crop fields between shelterbelts melts faster and absorbs water more completely (Rodin and Rodin, 2007).

A new challenge in afforestation in Russia occurred on 20 October 1948 when Stalin's plan of nature transformation in dry regions was adopted. It was entitled "Plan for Planting Field Shelterbelts; Implementing Crop Rotation; Constructing Ponds and Reservoirs to Increase and Stabilize Harvests in the Steppe and Forest-Steppe Areas of the European Part of the USSR". Large-scale forestation began nationwide as a result of planting forest belts as windbreaks. This project made use of scientific methods, advanced technology, and modem machinery and equipment. Forest research institutions found out that 3-4 hectares of forest strips per 100 hectares of arable land were a suitable margin of afforestation, which allowed getting sustainable and high agricultural crop. According to this norm, more than 5 mill. hectares of forest strips should have been established in the European part of the USSR. According to calculations of 1947, in 1948-1955 more than 948 thousand hectares would have to be planted, including field protection forest strips – 396,000 hectares, water regulating – 123,000 ha, ravines and gullies – 171,000 ha, on sands – 72,000 and in forestlands – 10,000 hectares (Koldanov, 1992).

According to this plan, the establishment within 1950-1965 of 8 large state protective forest strips was considered. Four of them were planned on watersheds (Penza - Kamensk, Kamyshin - Volgograd, Chapaevsk - Vladimirovka and Volgograd - Elista - Cherkessk) and four – on the banks of the rivers Volga, Don, Nothern Donets and Ural (Saratov - Astrakhan, Voronezh – Rostov-on-Don, Belgorod - Don and mountain Vishnevaya - Caspian sea). The data on the extent and the design of forest strips from planning to creation are presented in Table 8 (Agroforest Amelioration, 1970).

Along with the creation of eight state protective forest strips, it was considered to establish a field-protecting system of forest wood strips on the lands of collective and state farms, and also to plant trees on slopes of ravines and gullies, around ponds and other water reservoirs, and sand fastening and afforestation. In this complex of amelioration activities, a certain role was allocated to each kind of protective forest plantings. Altogether, they should ensure high and steady yield of agricultural crops.

The state protective forest strips created on watersheds and along rivers should basically carry hydrological functions. They should eliminate useless runoff on soil surface, raise humidity of the top layers of soils in agricultural areas adjoining to the strips, provide more intensive penetration of spring thawed snow into the bottom horizons, as well as increase forest ratio of the territory, promote improvement of climate and protect adjoining fields from dry winds and dusty storms. Therefore, the state strips on watersheds were designed from 780 up to 1140 meters consisting of three to four lines (each of 60 m wide) with inter-strip spaces of 300 meters. The state protective forest strips of such design covered the big area of a watershed and at the same time rather small amounts of lands were withdrawn from agricultural production for the creation of forest plantings.

The field examination of two state protective forest strips showed the following area distribution by major tree species (Table 9).

Table 8: ***Extent and Design of State Protective Forest Strips***

Name of the forest strip	Place	Extent of the strip, km	Width of the strip, m	Number of lines	Width of line, m	Inter-strip width, m
Penza-Kamensk	On watershed	600	780	3	60	300
Kamyshin-Volgograd	On watershed	170	780	3	60	300
Chapaevsk-Vladimirovka	On watershed	580	1140	4	60	300
Volograd-Elista-Cherkessk	On watershed	570	1140	4	60	300
Saratov-Astrakhan	On Volga river	900	200	2	100	-
Voronezh-Rostov-on-Don	On Don river	920	120	2	60	-
Belgorod-Don	On Middle Donets river	500	60	2	30	-
Mountain Vishne-vaya-Caspian Sea	On Ural river	1080	560-760	6	60	100-200

Plantings with a density of 60-80% were prevailing in state protective forest strips occupying 71.2% of the total area on the state strip of Kamyshyn – Volgograd, and 73% on the state strip of Penza – Kamensk. Plantings with lower density (40-50%) accordingly occupied 19% and 13.5%, and under-stocked (forest density of 30% and lower) plantings – 7.9% and only 3.9% of the total area.

The success of different main tree species growth in the state protective forest strips can be characterized by their average and maximal height and diameter. The ash trees in plantings have the worst growth and development, and hardly reach the height of 3.0-3.5 meters at the age of 10-12 years.

The given characteristics of forest plantings on the state strips evidently confirm the successes in this kind of artificial cultivation of forests. The created state protective forest strips in various geographical zones and soil conditions represent valuable scientific experience and know-how. Since the creation of the first state strips, forestry units have gained rich experience in afforestation in various soil and climatic conditions. Practice has gained much experience in such areas as soil preparation, selection of the steadiest wood and brush species, rational design of plantings, mixture and accommodation of species in plantings, and mechanization of works.

State protective forest strips have become a seed base for steppe afforestation. Based on incomplete data of forestry units of Volgograd province, only in 1962 in the state strip Penza – Kamensk more than 8,400 kilograms of clean seed were collected. In addition, the population of the nearest villages and farms collects seeds for their own needs such as cherry, apple, pears, currants and other fruits. State strips are a shelter for animals and birds combating wreckers of agricultural and forest cultures. Field camps of machine operators are based near the state strips, and strip margins are a place where bee hides appear during honey collection season. State strips near steppe settlements are kind of a green zone. They promote an enrichment of steppe landscape, raise aesthetics of environment and create conditions for healthy and cultural recreation of people.

Along with great successes, there were failures especially during the first years (1950-1953) in afforestation that resulted in low survival rate of planted trees, weak growth and even in their destruction in a few places. Among mistakes there are planting oak trees and other woody and shrub species on land ploughed in autumn for spring sowing with preparation of soil on depth only 27-30 cm. This soil did not contain enough accumulation of moisture and by clearing soil from weeds as well as planting oak trees under a cover of agricultural crops without follow up treatment was unsuccessful. There were also cases

Table 9: ***Example of Major Tree Species Planted in the State Protective Forest Strips***

Major tree species	Kamyshyn-Volgograd		Penza-Kavensk	
	hectares	%	hectares	%
Oak	591.9	12.4	4483.5	83.7
Pine	22.6	0.4	54.0	1.0
Small-leaf elm	2887.6	60.3	329.3	6.1
Common elm	30.2	0.6	24.6	0.5
Birch	-	-	38.5	0.7
Green ash	1099.2	22.9	415.4	7.8
White acacia	45.9	1.0	-	-
Ash-leaf maple	-	-	4.3	0.1
Apple tree and pear tree	71.9	1.5	-	-
Other species	47.0	0.9	4.8	0.1
Total	4796.3	100		100

of infringement of design in the selection of wood and shrub species and untimely treatment. Sometimes, less valuable species were planted on good soils, where oak tree growth should be relatively good. On the contrary, oak has been sawed on those soils, where it was not designed and could not grow well. After Stalin's death, most of the machine and amelioration stations were dismantled and the scope of afforestation works declined.

As can be seen from Table 11, practically only birch and poplar trees were planted (up to 92% of total area), and coniferous - only 62 hectares, or 3% of the area, while under the project they should occupy 1,041 hectares or about 30% of all plantings. Such irrational replacement of projected main species frequently results in a decrease of tree growth and failure of the planting.

Furthermore, during forest rehabilitation in the state strips of Altai territory and Novosibirsk province there were cases of infringement of agricultural techniques of soil preparation. Other reasons for plantation failures have been reported and include plantings on land ploughed in autumn for spring sowing instead of the preparation of the soil as stipulated by the project with deep plowing or deep soil loosening without mouldboarding; use of non-standard, uneven-aged planting material and even wild specimens; planting tree species which biological properties that do not correspond to soil conditions of these sites, especially common and black poplar on dry, heavy soils with deep subsoil waters; reduction of the stipulated amount of treatments and their full termination within 1-2 years prior to canopy closure of young plantings; and absence of autumn plowing of inter-lines and snow detention. As a result of these infringements, the survival rate of plantings decreased, their growth and development has slowed down; canopy closing has been delayed, and sometimes has resulted in a complete failure of the plantings.

A protection of agricultural lands from soil erosion, and the crops - from droughts and dry winds with the help of forest plantings are the most acceptable ameliorative actions. However, the work in this direction has declined dramatically in the country. For example, 20-30 years ago the Federal Forest Service being the contractor of forest amelioration works annually planted about 100-150 thousand hectares of field-protecting forest strips, plantings on ravines, gullies, sands and other marginal lands of collective farms and state farms. In 2006 only 4.8 thousand hectares of protective forests were planted.

Box 3. Windbreak Strips Design Based on Soil and Climatic Conditions

In recent years many scientific findings have been generated on the subject. One of the results was a new approach to the forest protective strip design. For example, it was found that under various soil and climatic conditions forest windbreak strips reach certain height, which should be taken into consideration in defining the distance between strips. On grey forest soils, podzol and alkaline chernozems plantations could reach 20-22 meters in height, on typical and ordinary chernozem - 16-18 m, on southern chernozems - 12-14 m, on dark-chestnut soils - 8-10 m and on light-brown soils - 6-8 meters. Hence, the distance between the longitudinal strips, expressed in meters, will be different. During protective forest shelterbelts growing on the agricultural lands the distance between longitudinal windbreak strips is recommended as follows: no more than 600 m - on grey forest soils, podzol and alkaline chernozems; 500 m - on typical and ordinary chernozems; 400 m - on southern chernozems; 350 m - on dark-chestnut and 250 m - on light-brown soils. On sandy soils this distance should be even less and not exceed 400 m in forest-steppe, 300 m in steppe and 200 m in semi-desert. The distance between cross strips should not exceed 2000 m, and on sandy soils - 1000 m. In the event of excess of the specified distances between longitudinal strips the positive effect of this cooperating system is lost because of the absence of an interrelation between them, and each strip becomes a stand-alone entity (Rodin and Rodin, 2007).

In 1965-1967, many successfully created state protective forest strips were examined in Altai territory, Novosibirsk, Omsk, Volgograd, Lipetsk and other provinces of the Russian Federation. The inspection has shown that in Altai territory on state strip Rubtsovsk - Slavgorod from the 4,886 hectares planned for afforestation 90.6% were accomplished, and on state strip Aleysk-Veselovka from 5,336 hectares only one half (48,6%) was successful. Depending on the soil the following types of forest planting were designed (Table 10).

Table 10: ***Distribution of Forest Strip Areas by Forest Types and Tree Species***

Name of the forest strip	Type of forest, %				
	Birch	Larch	Elm	Poplar	Pine
Rubtsovsk-Slavgorod	74.6	0.7	17.2	4.7	2.8
Aleysk-Veselovka	59.7	22.6	4.4	7.3	6.0

In Novosibirsk Province, 1,366 hectares of the state protective forest strip Novoselye - Burla were planted out of 1,466 hectares planned, or 93.2%, and on another one Chistoozernoye-Krasnozerskoye – 1,583 hectares, or 82.9%, from 1,910 hectares. Table 11 provides a comparison of projected and actually planted tree species in the forest strips.

According to the All-Russia Scientific Research Institute of Agro-Forest-Amelioration (VNIALMI) for guaranteed protection of agricultural lands from adverse factors, it is necessary to have 14 mill. hectares of protective forests, with the minimum need of 6 mill. hectares, compared with only 3 mill. hectares established until to date. By expert estimations, the areas of such plantings created in the last years do not exceed their natural loss. Now, there is no reliable information available about the condition of protective forests in Russia, and a nation-wide inventory is needed.

The Forestry and Agro-Forest-Melioration Division of All-Russian Academy of Agricultural Sciences (VASKhNIL) carries out systematic management of Forest Melioration in Russia. Many research institutions, academia, NGOs, forestry and other groups help in this development. Different topics are covered in special print media such as journals like “Forestry”, “Agriculture”, “The Bulletin of Agricultural

Table 11: ***Area of Projected and Planted Tree Species in the Forest Strips (in hectares)***

Major tree species	Projected	Actually planted
Larch	514	23
Pine	527	13
Pine with birch	-	26
Total pine domination	527	39
Birch	2106	1892
Birch with aspen	-	109
Birch with poplar	-	27
Birch with elm	-	22
Total birch domination	2106	2050
Poplar	205	449
Poplar and elm	-	24
Total poplar domination	205	473
Apple trees	24	-
Aspen	-	142
Elm	-	5
Maple	-	2
Total all species	**3376**	**2734**

Science", "Reports of VASKHNIL" and others as well as the newspaper "Forest Industry". The specialists in this field are trained in the Saratov Agricultural Institute and Novocherkassk Amelioration and Engineering Institute.

In 2006, the Federal Target Program "Preservation and restoration of soil fertility of agricultural lands and agro-landscapes as a national property of Russia for 2006-2010" was accepted by the decision of the Government of the Russian Federation (20.02.2006, #99). The Program gives substantial attention to the realization of hydro-ameliorative, agro-chemical and technological actions. During this period it is considered to establish 118,000 hectares of protection forests which is obviously not enough.

3. Research, Extension and Education Capacity

3.1 Research in the Field of Forest Rehabilitation

In 1892, the Forest Department awarded a grant to the Vasiliy V. Dokuchaev's Expedition on testing and calculating ways and methods of forest and water management in the steppe zones of Russia. As a result of this expedition not only a complete system of fight against drought was developed, but also the Russian forest field research has received substantial support. About 20 forest research areas (units) were set-up. "Proceedings on Forest Research in Russia" were published over the following 15 years (Tarasenko, et al., 2003).

This gigantic research effort has created a platform for forest amelioration and afforestation development on a scientific basis. After adoption of Stalin's Plan on Nature Transformation, in 1948 there were five research institutions working on the issues of agro-forest-amelioration and field protective afforestation; amongst them, there were three from Russia – the All-Russian Research Institute of Silviculture and

Case 2. Forests and Protective Forest Strips

The yield and growth performance related to protective shelterbelts may vary depending on a number of factors, in particular shelterbelt designs. According to the Russian Forest Melioration Research Institute, the mean agricultural crop yield under shelterbelt protection compared to unprotected crop fields is 14-33% higher in forest steppe, 14-24% higher in steppe, and 24-31% higher in dry steppe. In general, such growth for grain-crops is 18-23%, for industrial crops – 20-26%, fodder crops – 29-41%. On irrigated fields yield increase for grain-crops is 220-490 kilograms/ha, for grain corn – 760, green mass – 8200, potatoes – 2900, sugar beet – 5000 and raw cotton – 400-800 kilograms/ha. In forest plantations, the yield increase was observed in all zones for all crops within 10-40%.

As forest cover of arable lands increases, agricultural crop yield increases in all climatic zones for all crops. Optimal forest cover percentage of arable lands depends on shelterbelt height related to soil and climatic conditions, and tree species biology. In this regard, adopted optimal forest cover percentage for gray forest soils is 1-1.5%, alkali and rich black earth – 3%, south and deflated Kuban' black earth – 4% and chestnut soils – 5-6%.

In dry years exposed to dust storms, positive effect of protective plantations increases depending on forest cover of arable lands (see table below).

Table Case 2: ***Influence of Shelterbelts (as a Percentage of Forest Cover on Arable Lands) on Winter Crops Survival after Black Storms***

Forest cover, %, on arable lands	Winter crops mortality, %	Winter wheat yield metric centner/ha[1]
0.0 - 0.5	36.2	19.8
0.5 - 1.0	35.7	20.1
1.0 - 1.5	16.1	20.3
1.5 - 2.0	10.6	22.4
2.5 - 3.0	6.2	23.2

[1] 1 metric centner is equal to 50 kg

As a result of wind speed drop, shelterbelts promote decrease of mature grain fall. Strong wind drops harvested wheat swaths on areas unprotected with shelterbelts. It results in 3-4 metric centner/ha drop in grain output. It is not observed on fields protected by shelterbelts.

Positive effects of the shelterbelt system include conservation of crops during dust storms that happen in spring-summer and winter periods. Dust storms in winter result in winter crop freezing, deflation and covering with fine earth on exposed fields. There is no soil erosion in summer and winter periods and fertilizers application efficiency increases by 15-20% on fields protected with interconnected shelterbelt systems (Ivanov and Dryuchenko, 1969).

Forestry Mechanization (VNIILM, Pushkino), the All-Russian Research Institute of Agro-Forest-Amelioration (VNIALMI, Volgograd) and the Institute of Agriculture named after V.V.Dokuchaev (Moscow). The research network included 20 field research stations, and 40 basic field research units. More than 400 researchers have worked on the issue within this network (Koldanov, 1992).

It is noteworthy to remark that, in 1949, the complex expedition on research on the steppe-zone and semi-desert was established at the USSR Academy of Sciences. This body was a replication of 1892 Dokuchaev's expedition and included 199 scientists and researchers. Among them were outstanding

Russian scientists E. N. Pavlovsky (zoology), I. P. Gerasimov (geomorphology and geography), E. M. Lavrenko (geobotany), M. A. V. Elikanov (hydrology), S. S. Sobolev (soil erosion), A. T. Vatkin (phytopathology), P. I. Koloskov (climatology), P. V. Vasiliev (economics). In 1951, other remarkable scientists have joined this group: L. A. Ivanov (physiology of tree species), L. F. Pravdin (forest seeds), A. B. Zhukov (oak forests of industrial importance), K. V. Arnoldi and M. S. Gilyarov (entomology) and many others. St-Petersburg Forest Academy, Moscow Agricultural Academy named after K. A. Timiryazev and other institutions outside the Academy of Science were involved in the work of the expedition (Koldanov, 1992).

During the period between the 1950s and the beginning of the 1990s Russian forest science made good progress reflected in a set of published monographs, textbooks, manuals, regulative and technical documents. During this period various publishing houses printed a number of fundamental works such as “Trees and Bushes of the USSR” in six volumes (1949-1962), “Forests of the USSR” in five volumes (1966-1970), “Tree Species of the World” in three volumes (1982), “Forest Encyclopedia” in two volumes (1985-1986), selected works of experts in forest science, silviculture and tree planting G. N. Vysotsky (1960), V. V. Ogievsky (1966), G. F. Morozov in two volumes (1970-1971), V. N. Sukachev in three volumes (1972-1975) and others.

In the area of forest plantation and protective afforestation the substantive theoretical and practical provisions are stated in the following fundamental publications: A.V.Al’bensky “Tree Species Breeding and Tree Seeds” (1959), A. S. Jablokov “Tree Seeds Economy” (1965), V. V. Ogievsky “Forest Plantations of Western Siberia” (1966), V. J. Koldanov “Tree Species Composition Change and Reforestation” (1966), V. I. Rubtsov “Pine-trees Plantations in Forest-Steppe” (1969), V. V. Mironov “Afforestation of Sands in the Southeast” (1970), A. L. Bel’gard “Forest Science for Steppe” (1971), F. M. Kas’janov “Protective Afforestation on the Pasture Lands” (1972), N. P. Kalinichenko, A. I. Pisarenko, N. A. Smirnov “Reforestation on Cuttings” (1973), A. I. Pisarenko “Reforestation” (1977), V. P. Timofeev “Larch-trees Plantations” (1977), N. F. Kulik “Forest Amelioration of the Sandy Lands and Their Economic Development” (1977), A. R. Rodin “Fur-trees Plantations on Cuttings” (1977), I. I. Hanbekov “Reforestation and Protective Afforestation in Mountain Areas of the USSR” (1978), V. B. Larin “Cedar and Fur-trees Plantations” (1980), M. N. Prokop’ev “Pine-trees Plantations in Taiga” (1981), I. V. Shutov, et.al. “Forest Plantations” (1984), G. I. Red’ko and I. V. Treshchevsky “Man-made Forests” (1986), A. I. Pisarenko and M. D. Merzlenko “Creation of Artificial Forests” (1990) and many others.

Significant scientific and practical values in the field of forest zoning were introduced in the works of G. V. Krylova’s “Forests of Siberia and the Far East and their Vegetation Zoning” (1960) and S. V. Kurnaev “Forest Zoning of the USSR” (1973), which are still valuable nowadays.

The development of Russian approaches in silviculture and forestry has received attention in numerous works of forest research institutions, universities, Russian Academy of Science. These have found their reflections in publications edited by I. S. Melekhov “Concentrated Clear Cuts of Forests in the North” (1954) and “Bases of Clear Cuttings’ Typology and Its Value to the Forestry” (1959), “Taiga Silviculture” (1974), and other works like A.P.Shimanjuk “Natural Renewal on the Concentrated Clear Cuts” (1955), N. E. Dekatov “Activities for Forest Renewal at the Mechanized Timber Harvesting Operations” (1961), M. N. Prokop’ev “Understory of Fur-trees and Its Use” (1963), I. S. Melekhov “Main Timber Harvesting” (2d edition, 1966), “Forest Science” (1980) and “Silviculture” (1989), A. V. Pobedinsky “Main Timber Harvesting” (3d edition, 1980), and L. P. Rysin “Forest Typology in the USSR” (1982).

There were also many studies published on the relationship between forests and its environment. A significant contribution was made by A. A. Molchanov “Forest and Climate” (1961) and “The Influence of Forest on the Environment” (1973), V. V. Rahmanov in his fundamental works “Water-protective Role of Forests” (1962) and “Water-regulating Role of Forests” (1975), N. I. P’javchenko “Science on Forest Marshes” (1963), M. V. Rubtsov “Protective and Water-protective Forests” (1972), P. F. Idzon and G. S. Pimenova “Influence of Forests on Rivers’ Drain” (1975) and others.

The above list is only the top of the iceberg of the books published during this period on forests and dealing with forest regeneration. It is also necessary to mention a large contribution of forest scientists in elaboration and publishing of a huge amount of regulating, technical, methodical and reference books. More recent publications are listed in the reference section to this chapter.

From the 1990s to 2002, forest research and experimental activities were carried out within the federal forest research programs ”Forest Fire Protection, “Forests of Russia”, and “State Support of Nature

Reserves and National Parks". Research institutions took part in the activity of the following sub-programs:

- The Russian Forest;
- Forest Genetics: The Priority Directions of Further Development;
- Volga Revival;
- Complex Timber Utilization;
- Chernobyl and Ural programs on Radioactive Rehabilitation of Land and Population;
- EGASKRO program;
- Joint Russia-Belorussian programs, aiming at overcoming the consequences of the Chernobyl disaster

The sub-program "Forests" was developed and supported by the Federal Program titled "Ecology, Environment and Natural Resources of the Russian Federation (2002-2010)". The aim is to conserve and reproduce the forests as a raw material resource providing locals with timber and non-timber forest products and realizing that forest is an important nature-forming component when managed in a proper and sustainable way.

The existing system of scientific and research institutions and their traditional specialization together with scientific, research and pilot production network (forest pilot stations, pilot forestry farms) allows to ensure sufficient scientific support of forestry activities in different regions of the Russian Federation. Eight scientific and research institutions and one Central Engineering Bureau for Forest Machinery Design are under the Russian Ministry of Natural Resources providing scientific support in the field of forestry. Also, several institutions such as the International Forest Institute, Centre for Ecology and Productivity, Far East Institute of Biology and Soil of the Russian Academy of Science, a number of institutions managed by the Russian Academy of Agricultural Sciences and forest educational institutes such as Moscow State Forest University, St-Petersburg Forestry Academy, Voronezh Forestry Academy, Siberian State Polytechnic University and many others form a solid scientific base.

The number of forest staff of scientific and research institutes only under the Russian Ministry of Natural Resources amounts to 1,300 people, including 56 doctors and 250 Ph.D. holders. Post-graduate courses for training academic staff are organized in the All-Russian Research Institute of Forestry Mechanization and St.-Petersburg Forest Research Institute and the process of establishing a post-graduate course in the Far Eastern Forest Research Institute is completed. Academic staff concentrated in higher educational institutions and institutes of the Russian Academy of Science are of particular importance for forest research development (Rodin, 2003).

In recent decades particular emphasis in this country has been placed on artificial afforestation. A balanced system of planting material cultivation in forest reserves has been developed using means of complex mechanization, rich material on qualitative seed-growing organization has been collected, agro-technical tools of land cultivation have been elaborated as well as the methods of sowing and planting of forest crops, and agro-technical and forestry treatment thereof.

The quantitative composition and structure of future forests depends to a large extent on the achievements of afforestation. A clear rule of forestry that cutting and afforestation are synonyms acquires particular significance in view of certain emerging economic difficulties. The entire set of objectives - both the existing ones and those capable of emerging in the future on lands not covered with forest - is subjected to the process of artificial and natural afforestation and changes with time. Such a combination represents a generalized dynamic system, which takes into account the transition from extensive methods of economic activity to intensive ones (Pisarenko, 2003).

In the field of forest reproduction, particular attention should be paid to conservation and efficient use of the genetic potential of Russia's forests, scientific support of production of selectively improved seeding material in the forest nurseries, *inter alia* using chemical substances, physiologically active substances, bio-substances and fertilizers. The importance of genetics and selective directions of research has increased in many ways against the background of the drastic reduction of economically valuable natural resources and genetic impoverishment of forests and expansion of the zones of ecological disaster.

The establishment of a permanent forest selection framework on genetic and selection basis remains an integral part of the system of activities in the field of conservation and sound use of forest genetic resources. In the area of forest seed-growing an important direction of research development relates to the improvement of forest-seed zoning on the basis of studying the availability and cultivation of a new series of geographical, population and ecological varieties, conducting genetic and selection evaluation of forest-seeding plantations and permanent forest-seeding plots and the identification of synthetic sorts/ populations on this basis.

In a market environment an important role in forest restoration is played by the development of technologies and technical means providing harmonization of artificial creation of forest plants in the glades using natural restoration of forest.

Scientific research relating to the increase of resources and natural and ecological capacity of forests through cultivation of promising forest-forming species in forests, including introduced ones, establishment of plantations of food and technically valuable rapidly growing wild plants, restoration of forest vegetation in the vicinity of large metallurgic, mining, chemical and other enterprises are of particular importance from the environmental point of view.

The main problem of forestry in Russia has always been and is still related to forest fire, and forest science plays a very prominent role for its solution. Recently, the issues of improving the efficiency of forest fire safety on the basis of the concept of forest fire management have been widely discussed. The developments on the improvement of the methodology for assessing fire danger in the forest on the basis of weather conditions, forest fires behavior forecasts, harmonization of traditional and new modern means of fire safety advocacy and prevention of fire proliferation in the forest remain extremely significant. It is required to develop a system of early detection, determination of coordinates and surveillance of forest fires using GIS technologies, and new technical devices such as storm direction-finders, laser range-finders, space equipment, and aviation equipment.

Within the framework of this direction it is proposed to develop automatic technological complexes for forest fire control using remote methods of fire extinguishing and mechanical equipment on the basis of small vehicles with high crossroad capability with different types of engine and a set of spare equipment for forest fire extinguishing.

The main objective of research in the field of forest protection consists in the justification and development of environmentally safe integrated systems of activities (technologies) at different levels, which ensure effective protection of forests from harmful organisms, as well as conservation of biological diversity and forest productivity.

Promising research has been conducted in the management of the populations (numbers) of harmful insects and diseases, modeling of ecological processes and optimization of the strategy and tactic of forest protection using systemic analysis and modern information technologies.

Important research is also carried out in the field of surface and remote sensing methods of forest pathological monitoring, identification and survey of the seats of harmful organisms, methods of making different forecasts, patterns of decision-making and planning of forest protection activities on the basis of ecological and economic criteria, a set of preventive and active measures of protection, methods of assessment of efficiency and optimization of integrated systems.

It is required to increase the number and to improve the quality of biological and chemical substances (pesticides), technical ways and means of their use, development of methods for improving the efficiency of natural enemies of forest pests and a wider use of entomophags and biological means in the integrated systems of forest protection.

Research aimed at increasing plants' resistance to harmful organisms (insects and diseases instigators) as well as development of the prevention methods, particularly in nurseries and forest plants remain important (Rodin, 2003).

3.2 Education and Training in Forest Renewal

Russian forestry with its rich history has a well-developed system of forestry education. Although higher forestry education was rooted in Russia about 200 years ago, a good number of foresters were trained earlier - during the time of Peter the Great, who paid much attention to people's general education. This article presents a description on forestry education in Russia, current situation and some trends in forestry training. It also tries to highlight modern challenges of the forest sector.

In Russia, professional training of foresters began in 1800, when a "forstmeister class" was established within the Navy Cadet Corps in St. Petersburg. According to "Forest Regulations" (1802), Article 19, the Forestry Department was entrusted to establish forestry schools "for educating and teaching people in forestry sciences".

In 1888, ten vocational forestry schools were founded for the lower levels of forestry education. Each school has had 15 pupils. In 1917 there were 39 schools which provided two-year training predominantly in practical work for about 450 students.

Secondary forestry education was established in 1925-1930 on the basis of the former vocational schools. In 1928 there were five forestry secondary schools (250 pupils) in Russia, in mid-1950s — 16 (1,140 pupils), at the beginning of the 1960s – 34 (2,050 pupils), and since 1993 – 3 schools (2,950 pupils).

Special secondary forestry education – forestry colleges ("tekhnikum") were established as part of the forestry educational system reorganization in the 1920s. In 1965, forestry colleges enrolled over 10,000 students, and annual attendance was 3,100 day-time and about 1,900 extramural students. Now there are 23 forestry colleges with about 10,000 full-time and 6,000 extramural students in Russia, and annual attendance is more than 3,000 people. All of them are subordinated to the Russian Federal Forestry Agency under the Ministry of Natural Resources of the Russian Federation.

Forestry colleges offer basic knowledge in forestry, silviculture, forest ecology, forest estimation, tree planting, pest control, felling, sawing, forestry machinery operations and other technical skills. Eighteen of 23 colleges have their own forests with a total forest land area of about half mill. hectares. These forests are dedicated to forest specialist trainings through exposure to practical job experience and skills.

The first institution of forestry higher education was founded in 1803 in Tsarskoye Selo near St. Petersburg, although the name of "institute" for higher education organization was attributed to the forest institute in Kaluga. In 1803 and 1804 only 10 students were appointed annually; the staff included a supervisor, a forestland surveyor, a drawer and a translator. In 1863, the St. Petersburg Forestry Institute obtained a new status - the St. Petersburg Forestry Academy (till now). By 1917 only 4,200 professional foresters graduated from the St.-Pb. Forestry Institute/ Academy. During the Soviet period (1917-1991) the Academy trained about 50,000 forest specialists including such well-known experts as A. F. Rudzsky, D. M. Kravchinsky, G. F. Morozov, M. M. Orlov, M. E. Tkachenko, V. I. Sukachev, N. P. Anuchin and many others. In Moscow, the first forestry higher school was established in 1865 at Petrovsky Agricultural and Forestry Academy - now Timiriazev Agricultural Academy (Teplyakov, 1994).

Currently, forest higher education in Russia is offered in 50 universities, academies and institutes (forest engineering, polytechnic, technological and agricultural), 43 of which are united in the Teaching-Methodical Association on Forest Specialties and 14 of which provide training in forestry. These 43 institutions are spread unequally across the territory of the Russian Federation: the Urals Federal District has 3 institutions, the Russian Far East, Siberian and Southern Federal Districts have 5 institutions each, Central Federal District - 6, North-Western - 9 and Upper Volga - 10 institutions. The overall number of students is over 40,000, including more than 2,000 students from the CIS. Most universities are subordinated to the Ministry of Education and Science of the Russian Federation.

Among these students, a large group is trained directly in forest renewal and afforestation as well as indirectly as part of overall forest management systems in Russia (forest protection, pest control, mechanization of forestry works, forest economics, etc.). A major offer for forestry students is a qualified professional training course “Forestry and Landscape Design”, with two specializations one in “Forestry” and another one in “Gardening Works and Landscape Design” (Sanaev, V.G., Oblivin, A.N. and Kurnosov, G.A., 2003).

The basic duration of studies in forestry and forestry related professions is about 5 years. The forestry curriculum consists of several blocks of disciplines. During the first and the second year, students are trained in basic disciplines: general (mathematics, physics, chemistry), technological (geodesy, drawing, computer science, basics of forestry, machinery, logging and transportation), biological (forest botany, dendrology, forest soils, tree physiology, wildlife biology and hunting science basics, forest biometry and informatics) and social (philosophy, history, word culture).

During the third and fourth year, there are mostly general forestry disciplines provided: forest science (ecology), silviculture, timber cruising, forest inventory, forest management and planning, artificial regeneration and afforestation, pest control, forest legislation, remote sensing in forestry, forest genetics and forest tree breeding, forest economics, basics of wood science, forest guarding, safety of forest works, forest conservation and others. Furthermore, each department has its own specific disciplines to deliver to students at their specialized courses (forest entomology and forest pathology, biological methods of forest protection, tree nurseries and their maintenance, forest history, forest zoology and many others).

During the course students should prepare and defend several projects in main disciplines: silviculture, forest management and planning, artificial regeneration and afforestation, tree nurseries design, forest economics, forest roads construction and timber transportation, forest logging and safety of forest work. About one-third of curriculum students have to undergo summer field trainings or practices in subjects such as forest botany, geodesy, forest soils, dendrology, silviculture, forest inventory, artificial regeneration and afforestation, and forest machinery. Before the end of their studies, students must have done practical work at the forest enterprise and pre-diploma practices on chosen disciplines. After that they prepare and publicly defend their graduation project in the State Examination Commission for obtaining the qualification of an engineer for the chosen specialisation (Teplyakov, 2004).

4. Conclusions and Recommendations: Future Policies

Late in the 19th Century, i.e. at the end of the first century of existence of the Forest Department of Russia, Russian foresters formulated the principles of forest use: continuity and non-depleting use of forest resources. This also included the protection, safety and reproduction of forests, proceeding from sustainable management and conservation of the biological diversity of forest ecosystems to the improvement of their ecological and resource capacity, meeting the needs of society in forest resources on the basis of scientifically justified multi-purpose forest use. Therefore, the essence of forestry is not a simple use of forest but its reproduction. This determines the priority of forest restoration over forest use issues. It is not reasonable to develop them separately.

In planning forest restoration activities the main challenges are as follows:

a) creation of highly productive plants until they attain the age of quantitative and, in certain cases – technical maturity as a real basis for meeting the ever-increasing needs in specific assortments of forest products; *and*
b) cultivation of plants ensuring conservation of the forest ecosystem within a common system of a specific ecological zone as well as improvement of their climate regulating, water protection and soil protection role (Pisarenko, 2003).

In order to improve the efficiency of forestry production in the country it is necessary to address the following issues:

- To bring the planned volumes of forestry activities into conformity with recommendations on forest improvement developed on the basis of the actual availability of forestry funds and logistic and financial capabilities of enterprises;

Box 4. The Training on Reforestation and Afforestation

The training on reforestation and afforestation is carried out within the general professional discipline “Amelioration of Landscapes” and special discipline “Forest Cultures” (Artificial Forest Restoration). These disciplines include the following major issues:

- Forest seeds
  - Fruiting
  - Collection of seeds and fruits
  - Extraction of seeds from fruits and cones
  - Fruits and seeds storage
  - Quality control
  - Organization of seed sites;

- Tree nurseries
  - Organization of nursery’s territory
  - Soil preparation
  - Protection and fertilization increase in tree nurseries
  - Growing seedlings
  - Growing saplings in nurseries and plantation
  - Schooling
  - Planting materials inventory
  - Extraction from soil
  - Storage and transportation

- Planting trees
  - Basics of reforestation
  - Soil preparation for artificial forest restoration
  - Use of fertilizers
  - Sowing and planting of forest trees
  - Technical inventory and transfer of planting stock to forest lands

- Forest amelioration
  - Influence of protective forests on micro-climate and increase of agricultural crop
  - Forest strips for protection of fields (wind-breaking) and pastures
  - Soil erosion and control
  - Fixing and afforestation of sands
  - Protective strips at railroads.

- To introduce industrial tools of forest cultivation using advanced methods of labor organization;

- To ensure strict compliance with regulatory and technical documentation regulating the requirements to forest plants cultivation.

The main directions of forest cultivation improvement include:

- Development and introduction of advanced technologies and means of mechanization for the production of forest plants at the cutting area at minimum cost;

- Justification of the principles of increase in productivity and sustainability of forest plants of the main forest-forming varieties applicable to the categories of forest cultivation areas, technologies and the purposes of cultivated plants.

Since the methods of afforestation activities depend on forest-growing conditions and the economic situation, the intensity of forestry and afforestation should be considered from the zonal point of view. The main challenge in afforestation organization and planning relates to the optimum use of the potential capacity of forestry to cultivate highly productive plants of valuable forest varieties, and to conserve and improve their biological sustainability (Pisarenko, 2003).

An integrated approach is an opportunity to develop new organizational and operational forms that lead to structural changes resulting in dynamic and effective management of the forests. Systemic changes in industrial forest development methodology, in logging technologies and equipment must take place. This will assure a genuine shift to sustainable forestry by turning timber enterprises into integrated units operating on a permanent, and not short-term, basis. This approach is one of the major ways of addressing the economic, social and ecological challenges faced by the forest sector (Sheingauz, 1998).

In 1998, Russia celebrated the 200th anniversary of the establishment of the national special forest management body. It is due to the state management of forests that Russia managed to preserve its forests and wood-cover in the country - one of the highest in the world, as well as hereditary dynasties of foresters and forest managers. The main tasks facing the Russian forest sector in the 21st Century are as follows:

1. Elaboration of a federal program and regional models of sustainable forest management on the basis of criteria and indicators for sustainable forest management.

2. Elaboration of regional models of land use development that take into account the peculiarities of forestry as well as that of processing industries associated with it.

3. Development of a national system of forest products certification as an efficient market mechanism of sustainable forest management.

4. Development of mutually beneficial cooperation among different industries and population groups on the basis of replacement of the technology of logging and processing of forest resources with ecologically safe approaches.

5. Promotion of biological diversity conservation associated with the national forest fund and stabilization of the carbon balance of the boreal zone of the country using empty lands of the forest fund for the establishment of man-made forests that act as carbon sinks.

Use of information on the state of the forest fund lands for a balanced development of particular territories, creation of jobs as a result of infrastructure development, forest cultivation, forest use, wood-processing, paper and pulp, forest chemicals, agrarian and other types of activities and business on the basis of different forms of property on the territory of the forest fund (Roshchupkin, 2003).

There is an old Russian saying which should be remembered not only by forest specialists but by those who come to the green treasury to extract timber or to be more precise, to mine it:

"If you have a lot of forests, save them,
if you have a few forests, do not cut them,
if you have no forests, plant them."

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Spruce Plantation after Clearcut

Forested Landscape in the Russian Far East