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Report on:

CLIMATE CHANGE IMPACTS ON FOREST AND THEIR MANAGEMENT IN EASTERN EUROPE

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EXECUTIVE SUMMARY

The present report was elaborated in the framework of the FAO/SEUR activities on forest management in Eastern Europe, mainly the “Strategy for FAO and UNECE forestry and timber activities in Eastern Europe”, with the aim of gathering scientific information on the climate change issue, the possible threats in general, and especially for the forests and forest management in Eastern European countries.

The report shows that there are controversial views about climate change between those who believe that the threats are causes by human behavior, and those who believe that this is just a stage in a natural cycle.

There seem to be much more concerns for human impact scenario than for a natural phenomenon, and international organizations as well as national state institutions have have initiate policy options.

In 2007 the Intergovernmental Panel on Climate Change, predicted that the global temperature will increase between 1,4 º C and 5,8 º C by the end of the century, due to continued greenhouse gases emissions, expecting increases in heat waves, hot spells, extreme precipitations events, Asian summer monsoon, greater risk of droughts in summer in continental areas and more intense hurricanes in some parts of the world, changing of the water balance, among several calamities.

Among the several impacts forecasted for forest, the analysis done shows that the biodiversity will be one of the most damaged, involving a movement of flora and fauna species northwards, increasing mortality of some vegetable and fauna species, larger fires due to more extreme weather, and in general a decline of the landscapes.

But also the productivity of forests, the energy sector and the tourism and outdoor recreation will be affected. In the case of forests products, the markets will have to adapt, for example, using alternative species, changing the nature or location of the capital and machinery, adopting new technologies, etc

It is very important at the level of international community to find modalities to stop the trend of destroying the forests ecosystems and support the beginning of more intensive reforestation, i.e. reducing the forest fragmentation, selecting and matching species and provenance sites, favoring mixed and uneven forests, shorting rotations, etc.

For the adaptation of the forest to the climate change it should be developed capacities for planning, management and policy analysis, financial instruments, and also it should be stimulated development programmes for new forests products and services, the use of less environmentally hostile fuels, so the forestry sector should establish firm cooperation and coordination with all other relevant economic and administrative bodies and organizations.

Remembering the main functions of the forests, it can be said that the regulatory function of the local climate is on of the most important, but also carbon sequestration, which helps to slow the growth of greenhouse gas concentration in the atmosphere.

Within the forestry practices to keep carbon it's fundamental to name the afforestation and reforestation, adjusting of the rotation period and the forest management, related to a modification of the forestry practices to enhance carbon sequestration over time in Eastern Europe.

1. EXTENT OF CLIMATE CHANGE

Certain weather extremes, dynamic changes of some features in environment and recent researches on climate development, spread by the media, have waken up the interest of the public and concerned stake holders in the issue of climate change.

This issue has several dimensions. The uncertainty about future climate developments creates economic and social challenges, where a broad variety of stakeholders and even the public in general gets involved. Scientists as well as environmental NGOs are interested in the subject of the climate change, in order to raise their profiles and to increase their access to public and private funding. The media is interested in selling news on climate change, which can be distributed today, due to modern technologies, much faster and broader than in the past. The traditional industries get concerned about impacts on production, trade and consumption. New technology sectors, such as alternative energies, expect economic opportunities. Linked to the mentioned economic aspects, the public gets concerned about social impacts, e.g. in terms of employment respectively new employment opportunities. Many people, who did may be not consider themselves as “green” oriented, are waked up on environmental issues which might change consumer behavior significantly in broad terms. Last but not least, Governments who are responsible to insure long term sustainable development are challenged to respond to the discussion on climate change with adequate policy options.

For any policy respond the questions of major interest are: What is the extent of global climate change, and how this will impact the environmental and socio-economic aspects of future human welfare? People are also concerned about the reason of change climate, whether this issue is caused by human activities or is a natural phenomenon. Finally, due to limited resources, the various policy options should be evaluated and prioritized in order to respond to the issue effectively.

1.1. The climate change issue

1.1.1. Changes of climate in the recent past and impacts on environment

The “Surface Temperature Reconstructions for the Last 2,000 years” study assures that the temperatures at many individual locations were higher during the past 25 years than any other period of comparable length since A.D 900 (National Research Council (NRC), 2006).

Warming of the climate system is unequivocal according to the Intergovernmental Panel on Climate Change (IPCC) report on 2007, as is now evident from observations of increases in global average air and oceans temperatures, widespread melting of snow and ice, and rising

global mean sea level. The linear warming trend over the last 50 years is nearly twice that for the last 100 years. The atmospheric water vapor has increased the oceans temperature at depths of more than 3,000 m. has raised too. The oceans are absorbing more than 80% of the heat added by the climate system, and so the sea water is expanding itself.

The Intergovernmental Panel on Climatic Change (IPCC) announced in 2001 that "most of the warming observed over the last 50 years is likely to be attributable to human activities".

Potentially climate change will affect people, plants, and animals. Also scientists are working to better understand future climate change and how the effects will vary by region and over time (US EPA, 2006).

Some changes in the environment have occurred. Observed effects include sea level rise, melting glaciers, changes in the range and distribution of plants and animals, trees blooming earlier, lengthening of growing seasons, ice on rivers and lakes freezing later and breaking up earlier, and thawing of permafrost, etc. Human health can be affected directly and indirectly by climate change in part through extreme periods of heat and cold, storms, and climate-sensitive diseases such as malaria, and smog episodes (U.S. EPA, 2006).

To explain climate change, a computer model was used to simulate global climate from 1860 to 2000, taking into account natural factors, human factors, and then both set of factors combined. Only when natural and human factors were included could the model accurately reflect the cause of global-average temperature over the entire 140 year period, and specially the warming since the 1070s (UK Climatic Impacts Program (UKCIP), 2007).

1.1.2. Forecasting

While it seems somehow possible to put facts together with regard to climate change and its inputs to environmental, even more difficult is to forecast developments. Working out what will happen to our planet over the coming years is one of the most difficult tasks scientists have ever set themselves. The reason is that Earth's ecosystems are delicately-balanced in every way: the atmosphere, the oceans, the land conditions, and the animal and plant life are all interlinked, and when the heat is turned up, the whole system is disturbed (Woodland Trust, 2005).

The basic question is what would happen if there will be no significant changes made in the policy framework, which would affect climate change, the so called base line scenario or "business" as usual.

According to this scenario the 3rd Intergovernmental Panel on Climatic Change (IPCC) Assessment Report, predicts that the global temperature is going to rise by the end of the century of between 1,4º C and 5,8º C. "Continued greenhouse gas emissions at or above current

rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century". Maybe some expected changes are uncertain, but temperature rises is likely to affect countries throughout the World, and have a knock on effect with the precipitation and sea level rises (IPCC, 2007).

"Anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized" (IPCC, 2007).

There are various extreme weather features expected: (BBC, 2007):

- Increase in heat waves and hot spells.
- Greater risk of drought in summer in continental areas.
- Increase in extreme precipitation events.
- Hurricanes likely to be more intense in some parts of the World due to more rainfall and more intense winds.
- An intensification of the Asian summer monsoon is expected.
- Storm surges are expected to increase in frequency.

Scientists acknowledge that future changes due to climate change are difficult to predict. So, they have developed many different scenarios that policy-makers can use to forecast the range of changes that are possible. Their impact on surface temperature is estimated by computer models. None of these scenarios include policies specifically aimed at reducing CO2 emissions (Marian Koshland. Science Museum of the National Academy of Sciences, 2007).

1.2. Causes of Climate Change

1.2.1. The natural phenomena scenario

Predicting changes to our climate is very complex and the use of computer models has raised some criticism: "Sceptics say the scenarios of future climate change that are produced by computer models are deeply flawed" (Amos, J., 2000).

Scientists have been able to reconstruct a picture of the Earth's climate dating back decades to millions of years ago by analyzing a number of surrogate measures of climate such as ice cores, boreholes, tree rings, glacier lengths, pollen remains, and ocean sediments, and by studying changes in the Earth's orbit around the sun (U.S. EPA, 2006).

There are natural climate change drivers, such as changes in the Earth's orbit and volcanoes emissions, which often cause feedbacks within the climate system, (U.S.EPA, 2006) like changes in greenhouse gas concentrations or in ocean currents (which play a very significant role in the global heating distribution).

Studies of the Earth's previous climate suggest periods of stability, as well as periods of rapid change.

Scientist believe that human activity has contribute a significant increase of the earth's temperature, but there is also a sizeable group of researchers who do not agree with them, mainly because the climate on Earth has changed naturally in the long past.

According to William M. Gray (2000), professor of atmospheric science at Colorado university "human kind has little or nothing to do with the recent temperatures changes", and explains that the climate debate has been extended and exaggerated by those wishing to make gain from the exploitation on this subject, including the governments of developed countries, the media and the scientist who are willing to bend their objectivity to obtain government grants for researching on this topic.

Other scientists are less sceptical and it is the detail and severity of climate change which is frequently debated.

The Earth's climate has changed throughout history. From glacial periods, where ice covered significant portions of the Earth to interglacial periods where ice retreated to the poles or melted entirely, the climate has continuously changed (U.S Environmental Protection Agency (U.S. EPA), 2006).

The greenhouse effect is a natural warming process. Carbon dioxide (CO_2) and certain other gases are always present in the atmosphere. These gases create a warming effect that has some similarity to the warming inside a greenhouse, hence the name "greenhouse effect."

Increasing the amount of greenhouse gases intensifies the greenhouse effect. Higher concentrations of CO_2 and other greenhouse gases trap more infrared energy in the atmosphere than occurs naturally. The additional heat further warms the atmosphere and Earth's surface.

Some of the natural factors responsible for climate change are (EduGreen, 2006):

- Continental drift: the movement of the landmass drives a very slowly change in the flow of ocean currents and winds, which affect the climate
- Volcanoes: they throw out large volume of sulphur dioxide (SO_2), water vapor, dust and ash into the atmosphere, which can influence the climatic patterns for years. The gases and dust particles partially block the incoming rays of sun, leading to cooling.

- The Earth's tilt: changes in the tilt of the earth can affect the severity of the seasons. Changes in the Earth's orbit are also responsible of climate changes.
- Oceans current: they cover about 71% of the Earth and absorb twice as much of the sun's radiation as the atmosphere or the land surface moving vast amounts of heat across the planet.

Wind push horizontally against the sea surface and drive ocean current patterns.

Much of the sea heat that escapes from the oceans is in the form of water vapor, the most abundant greenhouse gas on Earth.

1.2.2. Human impact scenario

Indeed, there seem to be much more concerns for a human impact scenario than for looking at climate change as a natural phenomenon.

Since the Industrial Revolution (around 1750), human activities have added to the amount of greenhouse gases in the atmosphere, that absorb and emit heat. These gases are mainly: carbon dioxide, methane and nitrous oxide, but also ozone (O_3), water vapor and halocarbons (BBC, 2007). The burning of fossil fuels and vegetation has also resulted in emissions of aerosols that produce a refresh effect and a cloud of albedo, and also have influence in the life's cloud and the precipitations (U.S.EPA, 2006).

IPCC (2007) indicates that "The atmospheric concentration of carbon dioxide (CO_2) has increased by 31% since 1750. The current rate of increase is unprecedented during at least the past 20,000 years. About three-quarters of the anthropogenic emissions of CO_2 to the atmosphere during the past 20 years are due to fossil fuel burning. The rest is predominantly due to land-use change, especially deforestation.

Currently the ocean and the land together are absorbing about half of the anthropogenic CO_2 emissions. On land, the uptake of anthropogenic CO_2 very likely exceeded the release of CO_2 by deforestation during the 1990s.

"The atmospheric concentration of methane (CH_4) has increased by 1060 ppb (151%) since 1750 and continues to increase. Slightly more than half of current CH_4 emissions are anthropogenic (e.g., use of fossil fuels, cattle, rice agriculture and landfills). In addition, carbon monoxide (CO) emissions have recently been identified as a cause of increasing CH_4 concentration.

The atmospheric concentration of nitrous oxide (N_2O) has increased by 46 ppb9 (17%) since 1750 and continues to increase. About a third of current N_2O emissions are anthropogenic (e.g., agricultural soils, cattle feed lots and chemical industry).

Since 1995, the atmospheric concentrations of many of those halocarbon gases (CFCs) that are ozone-depleting and greenhouse gases (e.g., $CFCl_3$ and CF_2Cl_2), are either increasing more slowly or decreasing, both in response to reduced emissions under the regulations of the Montreal Protocol and its Amendments. Their substitute compounds (e.g., CHF_2Cl and CF_3CH_2F) and some other synthetic compounds (e.g., per fluorocarbons (PFCs) and sulphur hexafluoride (SF_6)) are also greenhouse gases, and their concentrations are currently increasing.

The total amount of O_3 in the troposphere is estimated to have increased by 36% since 1750, due primarily to anthropogenic emissions of several O_3-forming gases. This corresponds to a positive irradiative forcing of 0.35 Wm-2. O_3 forcing varies considerably by region and responds much more quickly to changes in emissions than the long-lived greenhouse gases, such as CO_2."

On the other hand, when humans transform land from forests to seasonal crops or from natural to urban environments, the regional climate system is altered. For example, clear-cut hillsides are significantly warmer than forests. Urban environments are also islands of heat produced by industry, homes, automobiles, and by asphalt's absorption of solar energy.

Changes in the land surface can have important effects on climate, for example, a change in land use and cover can affect temperature by changing how much solar radiation the land reflects and absorbs. Processes such as deforestation, reforestation, desertification and urbanization often contribute to changes in climate, in the place they occur. The amount of CO_2 taken up or released by the land surface is affected too by changes in the land cover, and also the usage and availability of water.

1.3. General options for climate change mitigation.

1.3.1. Technical solutions and policy options

Climate change challenges stakeholders (Governments, global enterprises, NGOs, etc.) to get together. Over recent decades, several conferences to discuss environmental issues have been held, and many agreements signed. The process began with the Stockholm Conference of 1972, but more concrete negotiations on the issue of climate change started in 1990. These negotiations resulted in the adoption of the United Nations Framework Convention on Climate Change, in 1992.

Probably the first great event, almost to keep the attention of many countries was the **United Nations Conference on the Environment** in Rio de Janeiro, called "Earth Summit" too, (United Nations, 1992). International organizations such as WMO, UNEP, UNESCO, FAO and others pointed out the possible changes of the climate system due to an increasing concentration of greenhouse gases. One of the most important results of the Earth's Summit was the Agenda 21, a collect of actions to reach de sustainable development in the XXI century. Between all the strategies proposed the fight against deforestation and mountain zones sustainable development, are important issues. It expresses the need of keeping the multifunctional of the woods and forestry lands by a proper institutional measure. Another outcomes of the Earth's Summit were the **"Framework Convention on Climate Change"**, focused o the stabilization of the atmosphere's greenhouse gases, and the **"**Forestry Principles Declara-

tion", first and main international consensus about a better use and keeping of all kind of forest.

The **Kyoto treaty** is the most important international instrument to fight against the climate change. It was established by the United Nation Framework Convention Climate Change (UNFCCC). It has the agreement of most of the industrialized countries to reduce their greenhouse gases emissions, about a 5% the global decreasing, in the stage from 2008 to 2012, compared with the 1990,s emissions, but each country has its own reduction percentage. It came into force on February 2005, after ratification by the Russian Federation, and with the exception of USA, responsible of a quarter of the global emissions.

After that agreement, global warming continued increasing, and so a number of nations approved an addition to the Kyoto protocol, in order to standardize a number of powerful and legally binding measures. So, in May 2006, the Bonn Conference saw delegates from 165 countries meet to discuss how to reduce emissions of heat-trapping gases and to respond to climate change impacts, to promotion economic incentives, to promote action to reduce emissions in industrialized and developing countries, and cleaner technologies.

Recently, in the **Intergovernmental Panel on Climate Change** (IPCC), Paris 2 February 2007, the fourth Assessment Report of the Work Group I of the IPCC has been exposed, which includes the last climate's evaluations and adds the new findings.

This way, scientists across the world are looking at the evidence of climate change, and are also using computer models to come up with predictions for our future environment and weather. However, the next stage of that work is looking at the knock-on effects of potential changes.

Assuming that human activities have a large impact on the climate, a significant part of the solution lies in human hands. We can bring down the use of fossil fuels, cut down on consumerism, increase recycling, halt deforestation and use more environment- friendly agricultural methods.

In the energy sector, emissions can be lowered if the energy efficiently is increased and if we shift to cleaner sources of energy which do not release any carbon dioxide. These include solar, wind, geothermal, and nuclear energy, but also burning wood is supposed a neutral impact on the CO_2 cycle.

The problem is that people who act by their own interests improve immediately benefits, while they can't feel immediately the lost caused by global warming, and they can't see an adjoining connection between action and consequence.

One of the solutions consists in teaching people in the advantages of an environmentally friendly behavior. One way is to take initiatives by Governments and other influential stake-

holder. For example, in the Sleipner's oil field (North See), the Norwegian Government's taxes make more profitable to capture and store the CO_2 than to free it at the atmosphere. (SEED, 2007)

A number of countries have cut down on the use of coal and have moved to cleaner sources of energy. Japan is a world leader in energy efficiency and the development of alternative energy sources (EduGreen, 2006).

E.g. vehicles running on cleaner technologies and fuel are being tested and strict emission laws are being adopted in the transport sector. Some countries have begun taxing industries, that is, the polluting industry has to pay society for the damage it has caused and is causing. Governments all over the world should see that forest cover is maintained because plants use carbon dioxide to grow and help remove it from the atmosphere. Forests are therefore, called 'sinks' of carbon dioxide. If trees are felled, reforestation should be immediately carried out. Wetlands are another ecosystem that play a very important role in maintaining ecological balance and thereby the stability of the climate. Preserving these areas has to be given top priority.

Biotechnology can be used to reduce the water requirement of crops, increase crop yield, and reduce the use of fertilizers and pesticides. Special strains of rice are being developed in laboratories that can grow with less water and lead to lower emissions of methane (EduGreen, 2007).

Many nonprofits and private sector companies and organizations are exploring ways to reduce greenhouse gas emissions by implementing sequestration and other agriculture/forestry wood projects. In addition, many state and federal programs support land use practices that help capture carbon dioxide as a by-product of cropland management of soils or forest management for timber. (U.S. EPA, 2006).

There are also a few options in the forestry field, as it can be seen in the chapter 3.2.

CO_2 can be captured in an artificial way, being separated from the rest of the combustion gases by using chemist solutions to dissolve it (SEED, 2007).

Nowadays it's being done at a small scale, mainly in the major emission sources: electricity generator buildings, iron, steel and cement production buildings.

2. POTENTIAL THREATS FROM CLIMATE CHANGE. ON FOREST MANAGEMENT IN EASTERN EUROPE

Forest management is potentially concerned with climate change in terms of impacts on forest ecosystems and their viability, but also in terms of forest management, by socio-economic means, such as employment, and income opportunities.

2.1. Impacts on forests

As indicated above, there are facts from the past and expectation in terms of climate change. With the current chapter, the intention is to describe potential threats to forest and forest management in Eastern Europe.

Talking about the threatened benefits provided by forest, precipitation amount and related water supplies in soil are a decisive ecological and physiological factor affecting the existence and production of forest ecosystems. Lack of water in soil, especially during vegetation period reflects negatively in the state of whole the forest ecosystem as well as in individual trees, particularly in weakening their physiological activity with subsequent reduction of total mass production and resistance against biotic pests and abiotic damages (Pajtík, J. et al, 2005).

Forest cover / Composition

According to various scenarios developed in relation with climate change, a warming process by 1,5 to 4°C is assumed in temperate zone of the north hemisphere. It is expected that due to it the potential area of tree species occurrence would shift northwards by 100 – 150 Km per each degree of Celsius/or to higher elevation above sea level, on average by 100 m per each 0,8 °C of the warming (Štefančík, I. et al, 2005).

Stability problems of the forest cover surfaced first in Europe in the eighties, following so-called forest decline symptoms. The issue is especially serious in countries like Hungary, which are situated on the border of the closed temperate forest belt. Research carried out since than has shown that there is a direct link between climate anomalies and health status (Rasztovits, E. et al, 2005).

The analysis of time-series data going back several decades makes it clear that except for some abiotic damages, in the Hungarian forests the individual elements of damage chains are built on each other through synergistic effects and usually maintain their effect for a long time. The first chain-loop is usually an abiotic, primarily climatic effect. Weather anomalies have a strong impact on the health status of Hungarian forests. Biotic “chain-loops” are only linked later to the degradation process initiated by water imbalance (atmospheric and soil

drought, heat days etc.). Beyond a certain point, when many unfavorable factors are already involved, the degradation process can not be stopped.

The modeling predicts the return of the large-scale forest decline observed in the eighties, if climatic conditions worsen (Rasztovits, E. et al, 2005).

In Hungary a high rate of mortality for sessile oak (*Quercus petraea*) can be observed in the zone where the summer water deficit reaches 270 to 300 mm. After the hot and dry summer of 2003, 160.000 m3 snag of beech (*Fagus sylvatica*) had to be cut in forests which were believed resistant and stable.

In the climatic frontier zones these zonal tree species – beech and sessile oak – are admixed. The natural regeneration of the indigenous admixed tree species is forbidden by the drought, so the proportion of not-native but very competitive (drought-resistant, fast-growing) tree species is getting higher (*Ailanthus altissina*, *Robinia pseudoacacia*). Because of the competitive exclusion beech and sessile oak disappear from these sites (Rasztovits, E.et al, 2005).

Biodiversity

Climate change would have an impact not only on the tree species, the concurrent decline and mortality of some tree species, particularly in the heaviest populated areas in the western, central and southern Europe, would have a major impact in soil vegetation, fauna and landscapes (Kellomäki et al, 2000).

Plagues

Insects are always presenting in nature, but thanks to a conjunction of factors, all of them stressing for the trees, they can develop to a pest and cause the weakness or even the dieback of an entire forest.

Deer populations, which are limited by extreme winter, cold and forage availability in spring, may also be favored.

Because of the plagues the forests are loosing their values in landscape from ecological, economical, esthetical and social point of view, due to the dieback of shoots and branches, and whole crown as well.

Insects life's cycle is usually controlled by a light-temperature rate. So a warmth of the air will shift their outbreak and feeding periods, and even multiply it, damaging the trees which usually are under more stress factors.

Precipitation deficits and higher daily air temperatures, and in some cases combined with less favorable site conditions and elevated SO2 concentrations, wounds caused by hail, frost, insects and pruning, have been associated by some authors to cause predisposition to some fungus attack; for example, in the case of Austrian and Bosnian pines with the pathogenic

fungus “Shaeropsis tip blight” (*Spaeropsys sapinea*). The most dramatic and severe dieback symptoms were observed in Austrian pine plantation locality Šušnjevica (Croatia) where all detrimental predisposing factors overlapped and broke down tree resistance capacity.

This dramatic event was spurred even further by the attack of several bark beetle species typical for the region, among which the most detrimental two were *Ips sexdentatus* Boerner and *Tomicus minor* Hartig.

Other kind of insects damaging the forest are the foliage browsing insects. In Ukraine the extent of some forest pest can be regulated by predicting distribution and dynamics. But the dates of vegetation period starting are changing as well as the relations between rates of air and soil temperature growth in spring. In the case of climate changes, the number of generations may be changed in some insects or additional diapauses can be formed to survive too dry or hot periods. Host species list can be changed too. All these life strategies can be calculated after known data, regularities, analogues analysis, etc. According to the scenarios of climate changes it was calculated that all predicted scenario of climate changes conditions will become worse for forest and better for insect pests (Meshkova, V., 2005).

Other insects which can become a plague are the xylophagues. Hot springs and summers with prolonged dry periods enabled the multiplication of xylophage’s populations, notably bark beetles, jewel beetles and loghorn beetles. The most suitable year in Croatia for the insect proliferation in one hand and physiological stress on trees in other, was undoubtedly the year 2003. Almost all of the most widespread tree species in Croatia suffered from various secondary xylophages attack. In some instances, first occurrences of certain insect species attacks were recorded. The intensity of tree loss due to the attack of most harmful insect species has not decreased even in the years following 2003. The salvage cuttings are still being applied in majority of the conifer forests while in some of the riparian forest communities new complications arose due to the problems of reforestation and land conservation (Hrašovec, B. et al, 2005).

Fire

The actual trend towards hotter and drier summer weather helps to create hotter, more intense fires. The hot weather dehydrates the fuel on the forest floor, creating perfect conditions for fire. The dryness of the weather also prevents soil dampening from rain (David Suzuki Foundation’s, 2007).

Fire experts are warning to expect larger fires in the future as a result of more extreme weather conditions (ABC News online, 2007).

Water Balance

Projections for Europe show a 1–2 % increase per decade in annual precipitation in northern Europe and an up to 1 % per decade decrease in southern Europe (in summer, decreases of 5 % per decade may occur). The reduction in southern Europe is expected to have severe effects, e.g. more frequent droughts, with considerable impacts on agriculture and water resources.

The genetic variability of most common tree species is probably large enough to allow them to acclimatize to average changes in temperature and precipitation. However, in the continental Europe increased droughts like in Hungary and forest fires may be the major risk for forests.

An increase in growth has been recorded in some countries in Central and Northern Europe, specially in that places where precipitation also increases, and it is supposed to be because of the increased CO2 and nitrogen deposition and changes in management practices, but in those countries with droughts, the regeneration success and the growth may be substantially limited (Kellomäki et al, 2000).

2.2. Socio-economic impacts

As shown in the chapter above climate change will significantly affect the distribution, condition, species composition and productivity of forest. The effects of climate change on forests will trigger market adaptations in forest management and in wood products industries and may well have significant effects on forest-based outdoor recreation. (Irland et al, 2001)

Throughout Europe, regular management with shorter rotation enhances the turnover of the current tree populations with a faster introduction of more resistant tree species and provenances into forest.

The supply of timber of pioneer species with short life span is expected to increase, producing a small-dimensioned timber (e.g. Czech Republic). Other countries like Slovakia might decrease the general timber supply in the future. But the effect on the dimension and quality of timber depends very much on thinning intensity and rotation length (Kellomäki et al, 2000).

These biological changes will develop complex regional changes in supplies of wood to sawmill and paper mills, producing effects on market prices. In turn land-owners and consumers will adapt in ways that cause further feed back effects on forests (Irland et al, 2001).

Adaptation in product markets may include using alternative species in the manufacturing process, changing the nature or location of capital and machinery, changing reliance on imports or exports, or adopting new technologies (Irland et al, 2001).

A warmer climate may increase the success of main agricultural crops, which may increase the competition between forestry and agriculture for land resources, with limitations for the increase of forest areas otherwise occurring.

In many European countries, forests and forest reserves provides the main opportunities to maintain the biodiversity and conserve rare and endangered species. The need to include exotic species or the preference of only a few resistant local species in order to maintain the productivity of forest would reduce the opportunity to implement the national and pan-european conservation programs (Kellomäki et al, 2000).

Tourism and outdoor recreation are expected to be affected significantly by climate change. This relates in particular to changes in ice and snow cover. The period for adequate winter sport conditions is expected to shorten. The period with summery conditions will lengthen (Perrels et al. 2005).

For the energy sector the demand for heating decreases and the demand for cooling will increase to some extent, so the overall effect is a sales loss for the energy sector. However, at the same time this is a cost saving for the energy consumers. Increased precipitation (in some places) and an earlier and possibly more extended period of snow and ice melting is favorable for hydro power potential, which is a cheap and emission-free source of electricity generation (Kirkinen et al., 2005).

3. OPTIONS FOR FOREST MANAGEMENT IN EASTERN EUROPE

While there are various activities undertaken to mitigate any potential threat from climate change, the questions remains what can be done about this issue and How forests can help to mitigate the climate change?

3.1. How to keep safe the forest of the climate change.

It is very important at the level of the international community to find modalities to stop the trend of destroying the forest ecosystems in all countries, and support the beginning of the more intensive reforestation, as it is the global interest of the Planet.

Martinic et al (2005) discuss in their paper how to adapt forestry to the new circumstances created by climate change. The necessity of including the forestry sector in the Action Plan for the implementation of the UNFCCC general measures for adapting forests to climate changes is also discussed. These measures aim to:

- reduce forest fragmentation
- select and match species and provenance to sites
- favour mixed, structurally diverse and uneven-aged forests, where possible

  adapt rotations
- adapt regeneration to altered reproduction and competition
- avoid monocultures
- survey pests and pathogens
- rehabilitate degraded forests
- protect and maintain rare habitats
- protect genetic stocks
- adapt planning processes
- adapt tending and thinning
- prepare for calamities and timber salvage
- adapt felling and skidding techniques
- adapt fire management to changes in climate and forest growth
- develop new financial support instruments

- improve educational skills for adapting forests to climate changes
- improve forest resource assessment and forest research
- eliminate additional stresses

The same report points out what should be the main activities of the forestry sector in Central Europe to adapt forest ecosystems to global climate changes.

- developing capacities and training for planning, management and policy analysis
- developing financial instruments for state-supported forest management, in particular for the purpose of subsidizing and financing investments in forestry, which includes implementation of general measures for adapting forests to climate changes,
- stimulating development programmes for new forest products and services, such as the use of forest biomass and waste energy, etc.,
- stimulating the use of less environmentally hostile fuels (replace fossil fuels and oils with those of plant origin).

In conclusion, to achieve the goals from the measures cited above, in their planning and implementation the forestry sector should establish firm cooperation and coordination with all other relevant economic and administrative bodies and organizations (Martinic et al, 2005).

3.2. How forestry contribute to mitigate the climate change

Forests play an important role in regulating the earth's temperature and weather patterns by storing large quantities of carbon and water. This regulatory function also has a deep effect on the local climate. Trees provide shade, which turn lowers summer temperatures and prevents the soil from drying out. They reduce heat loss from the ground in winter and prevent storm damage by providing shelter from wind (The Forest and the European Resource Union Network (FERN), 2007).

Plants remove carbon dioxide from the air through a process known as carbon sequestration. Planting trees, practicing sustainable forestry, using conservation tillage on croplands and other agricultural and forestry practices can help slow the growth of greenhouse gas concentrations in the atmosphere.

The carbon cycle is the term for the flow of carbon between the atmosphere, land, ocean and biosphere. Human activities are releasing increased amounts of carbon dioxide and other greenhouse gases into the atmosphere, causing the atmosphere to heat up. Around half of this surplus carbon dioxide is then taken up in carbon 'sinks' on the land and sea surface, mitigating the extent of global warming - at least for now (ESA, 2007).

The concept of carbon sinks according to the Forest and European Resource Network (FERN, 2007), is based on the natural ability of trees, other plants and the soil to soak up carbon dioxide and temporarily store the carbon in wood, roots, leaves and the soil.

Sequestration of carbon dioxide in forest biomass is assumed as one of important forest ecosystem functions in the biosphere. Forest ecosystems are represented also by other potential carbon sink - forest soils including the most prominent upper part - humus forms. In the soil ecosystem compartment, there could be fixed considerably more carbon, compared to the above and below ground biomass. Sustainable forest ecosystems should contain 10 – 200 t/ha of carbon in holorganic layers (Podrázský et al, 2005). The soil compartment can fix 1 – 3 t/ha of carbon annually, depending on the stand structure, species stand composition, site conditions and also on the ameliorating treatments.

Simultaneously, forests absorb CO_2 and release oxygen; we can evaluate a positive effect on the balance of oxygen and carbon dioxide in the atmosphere, as also in reduction of glass house effect. Among other profitable and common benefit functions, newly created ecosystems will be able to absorb 7,098,000 t CO_2 and enrich atmosphere with 5,420,000 t O_2 (Drazic et al, 2005).

According to recent inventory results, the average quantity of carbon stored in Hungarian forests is estimated to 211 t/ha, out of which 76 t/ha is stored in the above-ground biomass, the rest of 135 t/ha in the soil. For the total forest cover, this amounts to approximately 377 million tons. The annual wood increment adds 3.2 million tons per year, out of which only 75% is utilized. The net quantity of accumulated or permanently bound (in wood products) carbon is 2.04 million tons annually, which is only a fraction of the annual carbon emission of the country, ca. 16 million tons. Changes in the sequestered quantities depend on changes in growth and health status of the forest stands. Newest investigations show accelerated increment on national level as compared to conditions 20 years ago.

Obviously, adverse changes in climate (precipitation loss, increasing temperature) are still balanced by the elevated CO_2 level and by relatively high doses of nitrogen deposition (Führer et al 2005).

Within the forestry practices to sequester carbon, the most popular are afforestation and reforestation. Afforestation is referred to planting trees on lands previously not in forestry (e.g., conversion of marginal cropland to trees), and reforestation is referred to lands that in the more recent past were in forestry, excluding the planting of trees immediately after harvest (e.g., restoring trees on severely burned lands that will demonstrably not regenerate without intervention) (EPA, 2007).

Planting trees can make a considerable contribution to reductions in CO_2 levels and can act as a carbon reservoir since it wouldn't still keep the carbon locked in its biomass out of the atmosphere. Thus, to postpone increases in CO_2 levels in the atmosphere by afforestation, new plantations have to be established annually.

In the long term, a managed forest stand does not sequester carbon since all of the biomass that is built up during the rotation period is harvested. So, to increase the amount of carbon in biomass at a regional or national level the amount of forest land has to be increased or the forest management has to be improved (Erikson et al, 2006).

Adjusting the rotation period could be an important forest management strategy to reduce atmospheric CO_2 levels since this variable affects the carbon storage capacity of both the biomass and soil (Kaipainen et al. 2004). Species with long rotations generally have larger average carbon stocks than species with shorter rotations, and can therefore store more carbon in their biomass (Maclaren 2000).

Conifers fix generally more carbon dioxide, comparing to broadleaved species, with some exceptions. Alder stands in appropriate site conditions supported by liming and fertilizing, sequester more carbon in humus form compared to conifer tree species on the same locality. On the other side, net carbon output can be observed in impropriate forest management practices, liberating CO_2 through accelerated humus mineralization (Drazic et al, 2005).

Forest preservation or avoiding deforestation can also protect forests that are threatened by logging or clearing, and this way avoids CO_2 emissions via conservation of existing carbon stocks, e.g.: illegal logging.

Another important climate change mitigate strategy regarding to the soil carbon sinks includes the forest management: modification to forestry practices that produce wood products to enhance sequestration over time (e.g., lengthening the harvest-regeneration cycle, adopting low-impact logging). Increases carbon storage by sequestration and may also avoid CO_2 emissions by altering management (EPA, 2007).

Using wood from a sustainable-managed forest as fuel instead of oil, coal and natural gas, can also reduce the global warming (FAO, 2007).

The bioenergy can help reduce dependence on fossil fuels and resulting emissions and can offset carbon emissions by serving as carbon "sinks". CO_2 is removed from the atmosphere and stored in the tree biomass. However, the newly created forest is a carbon sink only while the carbon stock continues to increase. Eventually an upper limit is reached where losses through respiration, death and disturbances from fire, storms, pests, diseases or harvesting approximately equal the carbon gain from photosynthesis.

Harvested wood from these forests is converted into wood products, which also act as a sink until the decay and destruction of old products matches the addition of new products. Since harvest cannot be increased beyond a sustainable limit, the forest and the products derived from it have a finite capacity to store CO_2 from the atmosphere; they act as a perpetual carbon store only when managed sustainably, and otherwise release the carbon previously fixed (FAO, 2001).

Wood products are carbon stores, rather than carbon sinks. Their carbon continues to be stored through their lifecycle: use, re-use, recycling and recovering by burning or decay. Carbon accounts for about 49% of the mass of a wood product.

With an estimated European wood product stock of about 60 million tonnes, the carbon stored in wood products has a significant role to play in reducing Climate Change

The use of wood in building and construction stores carbon and substitutes carbon dioxide emissions of competing materials. Depending on reference material, one cubic meter of wood reduces carbon dioxide emissions by 3-5 tones compared to traditional building materials.

In this way the forestry strategy must be to maintain carbon sequestered in forest ecosystems, including an expanded program to encourage better management of private forest and programs to increase the recycling of wood fiber. This management must include proper fire protection measures, to avoid the lost of all the carbon stored in the forest biomass; wildfires and in general natural disasters may release large amounts of carbon to the atmosphere in a short period of time (SEDJO, 2006).

4. BIBLIOGRAPHY

Publications

Amos, J., (2000). *Questioning global warming*, BBC News World edition, viewed March 2007.

http://newsvote.bbc.co.uk/1/hi/sci/tech/1017204.stm

Drazic, M., Drazic, D., Bojovic, S., (2005). Climate change – forest Ecosystems & Landscapes.In: *Natural and Anthropogenous Forest Ecosystems of Serbia in the function of glasshouse effects reduction.* Forest Research Institute Svolen, 19-22 October 2005, 29-30.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/PRESENTATIONS/drazic%20zvolen.pdf

Eriksson, E; Johansson, T, (2006). *Effects of Rotation Period on Biomass Production and Atmospheric CO2 Emissions from Broadleaved Stands Growing on Abandoned Farmland.* Silva Fennica 40(4): 603–613.

http://www.metla.fi/silvafennica/full/sf40/sf404603.pdf

Gray, W.M. (2000). *Viewpoint: Get off warming bandwagon*, BBC News World edition. Viewed 29 March 2007,

http://news.bbc.co.uk/2/hi/in_depth/sci_tech/2000/climate_change/1023334.stm

Führer, E., Csaba M. (2005). Climate change – forest Ecosystems & Landscapes. In: *Effect of Climate Change on Carbon Sequestration and Stability of the Hungarian Forest Cover*, Forest Research Institute Svolen, 19-22 October 2005, 37-38.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/PRESENTATIONS/114%20Zvolen.pdf

Hrašovec, B., Diminić, D., Pernek, M., Pilaš. I., (2005): *The uprise of xylophagous insect populations in Croatia as a consequence of climatic changes*. Faculty of Forestry University of Zagreb & Forest Research Institute Jastrebarsko, Croatia. Svolen, 19-22 October 2005, 14 pp.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/PRESENTATIONS/Climatic%20change.pdf

Irland, L.C., Adams, D., Alig, R., Betz C.J., Chen C., Hutchins M., McCarl B.A., Skog K., Sohngen B.L. (2001): *Assessing Socioeconomic Impacts of Climate Change on US Forests ,*

Wood - Product Markets, and Forest Recreation. • BioScience 753, September 2001 / Vol. 51 No. 9

http://agecon2.tamu.edu/people/faculty/mccarl-bruce/papers/844.pdf

Kaipainen, T., Liski, J., Pussinen, A. & Karjalainen, T., (2004). *Managing carbon sinks by changing rotation length in European forests*. Environmental Science & Policy 7: 205–219.

Kellomäki, S; Karjalainen, T; Mohren, F; Lapveteläinen, T. (2000). *Expert Assessments on the Likely Impacts of Climate Change on Forests and Forestry in Europe*. European Forest Institute.

http://www.efi.fi/attachment/f5d80ba3c1b89242106f2f97ae8e3894/595f8f71578118c8ac3d4cd0e5b73efa/EFI_Proc34.pdf

Kirkinen, J., Martikainen, A., Holttinen, H., Savolainen, I., Auvinen, O. and Syri, S. (2005). *Impacts on the energy sector and adaptation of the electricity network business under a changing climate in Finland*. FINADAPT Working Paper 10, Finnish Environment Institute Mimeographs, Helsinki, 36 pp.

Maclaren, J.P. (2000). *Trees in the greenhouse – The role of forestry in mitigating the enhanced greenhouse effect*. Rotorua, New Zealand. Forest Research Bulletin 219. 72 p.

Martinic, I., Sporcic, M. (2005). Climate change – forest Ecosystems & Landscapes. In:*Integrating Global Climate Changes into Core Forestry Activities.* Forest Research Institute Svolen, 19-22 October 2005, 44-46.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/proceedings_climate-change.pdf

Meshkova, V., (2005): *Global climate changes impact on foliage browsing insects distribution and dynamics.* Ukranian Research Institute of Forestry & Forest Melioration, Svolen, 19-22 October 2005, 21 pp.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/PRESENTATIONS/meshkova.pdf

Pajtík, J., Ištoňa, J. (2005). Impacts of precipitation on dynamics of tree species diameter growth. Forest Research Institute Svolen, 19-22 October 2005, 101.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/proceedings_climate-change.pdf

Perrels, A; Rajala, R., Honkatukia, J. (2005): *Appraising the socio-economic impacts of climate change for Finland.* Finnish Environment Institute.

http://www.environment.fi/download.asp?contentid=45371&lan=en

Podrázský, V., Ulbrichová, I. (2005): Climate change – forest Ecosystems & Landscapes.In: *Capture of Carbon in Humus Form in Mountain Forest in the Ore Mts*. Forest Research Institute Svolen, 19-22 October 2005, 116-117.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/proceedings_climate-change.pdf

Rasztovits, E., Berki, I. (2005): Climate change – forest Ecosystems & Landscapes.In: *Forest Health and Species Composition Changes on Sites on the Closed Forest Limit.* Forest Research Institute Svolen, 19-22 October 2005, 107-108.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/proceedings_climate-change.pdf

Štefančík, I., Kamenský, M. (2005): Climate change – forest Ecosystems & Landscapes. In: *Natural Change of Tree Species Composition in mixed Spruce, Fir and Beech Stands under Conditions of Climate Change*. Forest Research Institute Svolen, 19-22 October 2005, 53-55.

http://www.fris.sk/en/lvu/podujatia/2005/climate_change/PRESENTATIONS/Stefancik-Konferencia%202005.pdf

Web Pages

ABC News online (2007), *Climate change increases risk of megafires*, viewed 28 March 2007,

http://www.abc.net.au/news/newsitems/200703/s1868939.htm

Alley, R. et al 2007, *The third Assessment Report of the Working Group I of the Intergovernmental Panel on Climatic Change (IPCC)*, viewed 16 February 2007,

http://www.ipcc.ch/SPM2feb07.pdf

BBC (2007), *Climate change*, viewed March 2007.

http://www.bbc.co.uk/climate/

David Suzuki Foundation (2007), *Climate change and fire*, viewed 28 March 2007,

http://www.davidsuzuki.org/Forests/Forests_101/FIRE/Climate_Change.asp

EduGreen (2006): *Causes of Climate Change*, viewed June 2007.

http://edugreen.teri.res.in/explore/climate/causes.htm

ESA 6 (2006): *La qualita dell'aria: uno sguardo dell spazio*, viewed 29 March 2007,

http://www.esa.int/esaCP/SEME2SNZCIE_Italy_1.html

FAO Corporate Document Repository (2001): *Wood energy, carbon sinks and global climate change,* viewed 12 April 2007,

http://www.fao.org/docrep/005/y4450e/y4450e07.htm

FAO Newsroom (2007): *Forest and climate change*, viewed 27 March 2007,

http://www.fao.org/newsroom/en/focus/2006/1000247/index.html

FERN - The Forests and the European Union Resource Network (2007): *Carbon sinks. What they are and why they undermine the Kyoto protocol*, viewed 28 March,

http://www.fern.org/pages/climate/carbon.html

Interngovernmental Panel on Climate Change (IPCC) (2007), *Climate Change 2007*. Last viewed June 2007.

http://www.ipcc.ch/

Marian Koshland. Sience Museum of the National Academy of Sciences (2007), *Land Use Changes*, viewed 29 March 2007.

http://www.koshland-science-museum.org/exhibitgcc/causes09.jsp

Sedjo, R., (2006): *Forest and biological Carbon Sinks after Kyoto*. Resources for the future, viewed 16 April 2007.

http://www.weathervane.rff.org/policy_design/Carbon%20Sinks/RFF-BCK-CarbonSinks.pdf

SEED (2005), *La energia y el cambio climatico mundial. La tragedia de los comunes*, viewed 5 March 2007,

http://www.seed.slb.com/es/scictr/watch/climate_change/tragedy.htm

UK Climatic Impacts Program (UKCIP), *Climate change*, viewed 14 February 2007,

http://www.ukcip.org.uk/climate_change/

United Nations (1992): *United Nations Conference on the Environment and Development*, Rio de Janeiro, viewed June 2007.

http://www.un.org/geninfo/bp/enviro.html

U.S. Environmental Protection Agency, (U.S. EPA) (2006), *Agriculture and Forest Land,*, viewed June 2007,

http://www.epa.gov/climatechange/wycd/agforestry.html

U.S. Environmental Protection Agency, (U.S. EPA) (2006), *Past Climate Change*, viewed 2 March 2007,

http://www.epa.gov/climatechange/science/pastcc.html#ref

Woodland Trust (2005), *Climate change. Something's happening to our planet*, viewed 1 March 2007,

http://www.naturescalendar.org.uk/NR/rdonlyres/78321DC5-E689-4578-9321-24F19F27F917/0/climatechange.pdf