COST action FP0703 – ECHOES

Expected Climate Change and Options for European Silviculture

COUNTRY REPORT

BULGARIA

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Introduction

Bulgaria is a relatively small country (111 thousand square km) situated on the central part of the Balkan peninsula. At present, the Bulgarian forest fund area (total forest area in administrative terms) accounts for 34% of the country's territory. Approximately 87% of the forest fund is covered by forests. During the past 40 years, the Bulgarian forest fund increased with 8.4% – from 3.6 million ha to 3.9 million ha.

I. Impacts

I.1. Observed impacts:

Climatic elements:

Average temperature.

According to the data from the long-term monitoring on representative forest ecosystems dominated by Scots pine (green line), spruce (blue line), beech (yellow line) and oaks (red line), there are smooth trend for both increasing the divergence between years and the average temperature (fig.1).

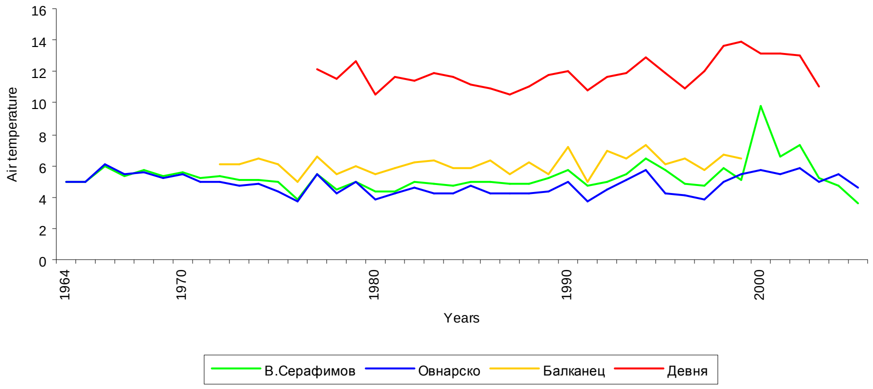

Fig.1. Air temperature in representative forest ecosystems in the period 1964–2005: Green line – V. Serafimov climatic station (CS), South Rila mountain; Blue line – Ovnarsko CS, North Pirin mountain; Yellow line – Balkanets CS, Central Balkan range; Red line – Devnya CS, North-Eastern Bulgaria (Raev, 2006)

Precipitations

The monitoring data about annual precipitations in the same representative forest ecosystems shows clear trend for increasing the divergence from year to year, as well as smooth trend for diminishing the quantity of the total precipitations in low regions (oak vegetation belt – red line)

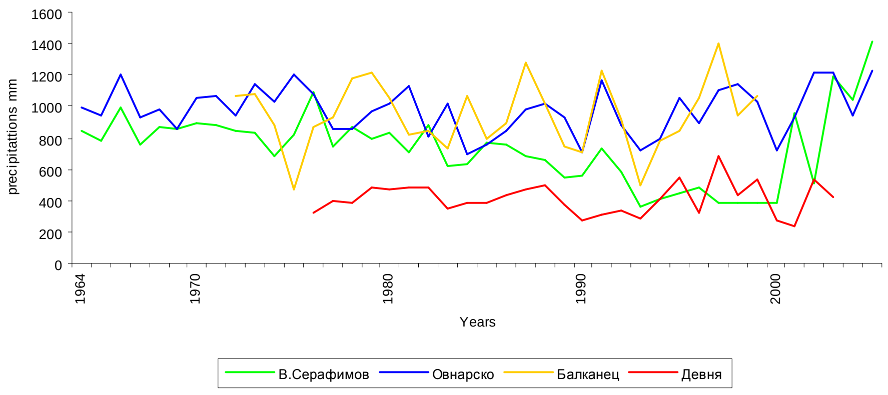

Fig.2 Precipitation quantity in representative forest ecosystems in the period 1964–2005. Green line – V. Serafimov climatic station (CS), South Rila mountain; Blue line – Ovnarsko CS, North Pirin mountain; Yellow line – Balkanets CS, Central Balkan range; Red line – Devnya CS, North-Eastern Bulgaria (Raev, 2006)

Disturbances and extreme events

<u>Forest fires</u>

There are a significant increasing the numbers of the forest fires in Bulgaria during the last 10 years (fig.3). One of the main reasons for this events is the hot summer with low and irregular precipitations during the vegetation period in the years 1993, 2000, 2001 and 2006.

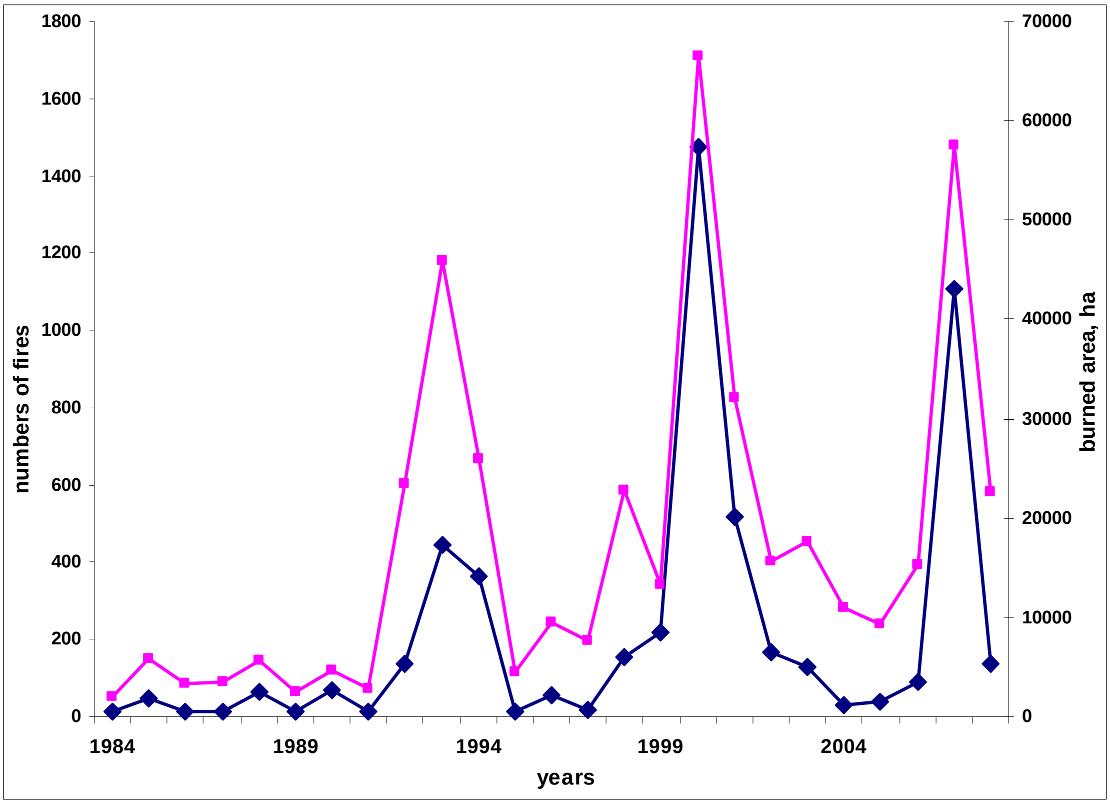

Fig 3. Number of forest fires and their area in Bulgaria, 1994–2008. Blue line – numbers; red line – burned area (State Forest Agency – 2008).

Damages caused by wind, frost and storms.

There are regular monitoring system in Bulgarian forest, for tracking and prevention different abiotic and biotic damaging factors. Their distribution for the last 3 years is indicated in Table 1.

Table 1. Distribution of damaged areas by type of damage.

Damage type	**2006**			**2007**			**2008**		
	Affected area (ha)			**Affected area (ha)**			**Affected area (ha)**		
	Slight	**Strong**	**Total**	**Slight**	**Strong**	**Total**	**Slight**	**Strong**	**Total**
Abiotic	858,86	138,93	997,79	703,98	35,24	739,22	291,16	69,19	360,35
As a percentage of total damaged area	10.0	8.3	18.3	9.1	3.2	12.4	3.6	4.1	7.7
Windthrow and windbreak	730,40	108,73	839,13	327,49	12,44	339,93	191,25	45,52	236,77
Snowbreak, Snow uprooting	124,48	4,83	129,31	360,50	18,50	379,00	76,11	13,02	89,13
Drought	0,21	0	0,21	0,04	0,12	0,16	20,55	10,17	30,72
Frost	0,16	2,42	2,58	2,36	2,74	5,10	1,95	0,45	2,40
Floods	0,45	13,71	14,16	1,98	0	1,98	0,05	0	0,05
Hailstorm	3,16	9,24	12,40	11,61	1,44	13,05	1,25	0.03	1,28
Forest fires	96,73	114,23	210,96	118,32	70,87	189,19	824,89	839,42	1664,31
As a percentage of total damaged area	1.1	6.8	7.9	1.5	6.5	8.0	10.3	49.2	59.4

I.2 Expected impacts

Forest resources dynamics (EFISCEN based simulations)**.**

It is investigated by four scenarios developed for the forest resources model EFISCEN. The traditional or base scenario shows potential forest resources development following current levels of silvicultural treatments. The pessimistic scenario take into account some negative tendencies in the economic situation (for example lack of investments for additional afforestation) as, well the negative effect of disturbances caused by climate changes – low level of stability of young forests, higher and earlier mortality for the mature ones, low level of natural regeneration etc. Comparison between Base and Pessimistic scenarios could suggest some general understanding for the potential growing stock annual increment decrease.

Increment:

The potential loss of increment is about 1 cub.m/ha/year, which is annual amount of 3,5 mln. cub.m (fig.4)

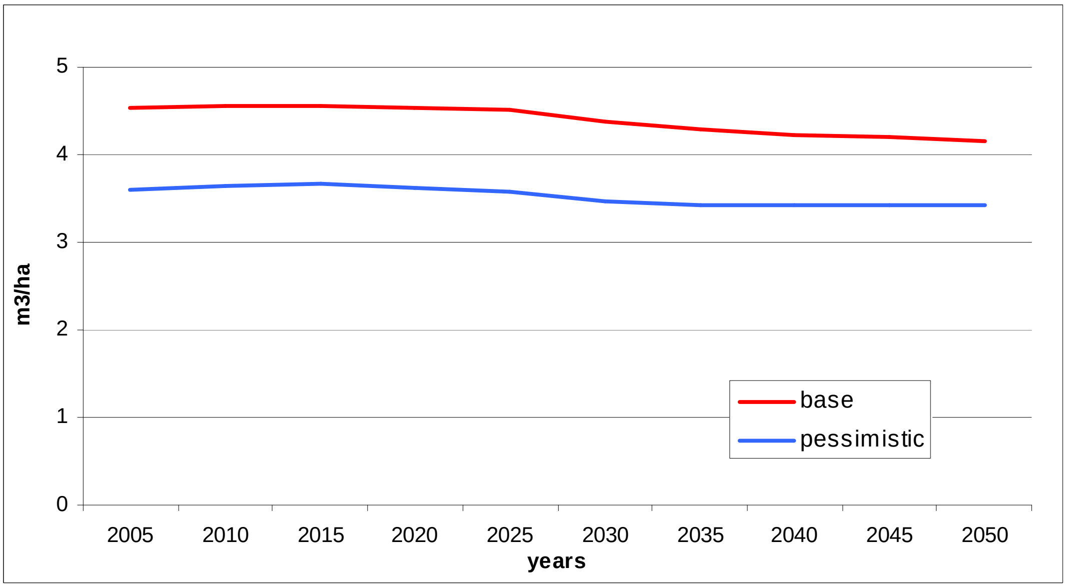

Fig. 4. Annual average increment per ha, total for the BG forests, based on EFISCEN simulation (2000-2050)(Kostov and Rafailova, 2008).

Volume per ha

There are significant losses of biomass (growing stock) of Bulgarian forest, according to the pessimistic scenario (fig.5).

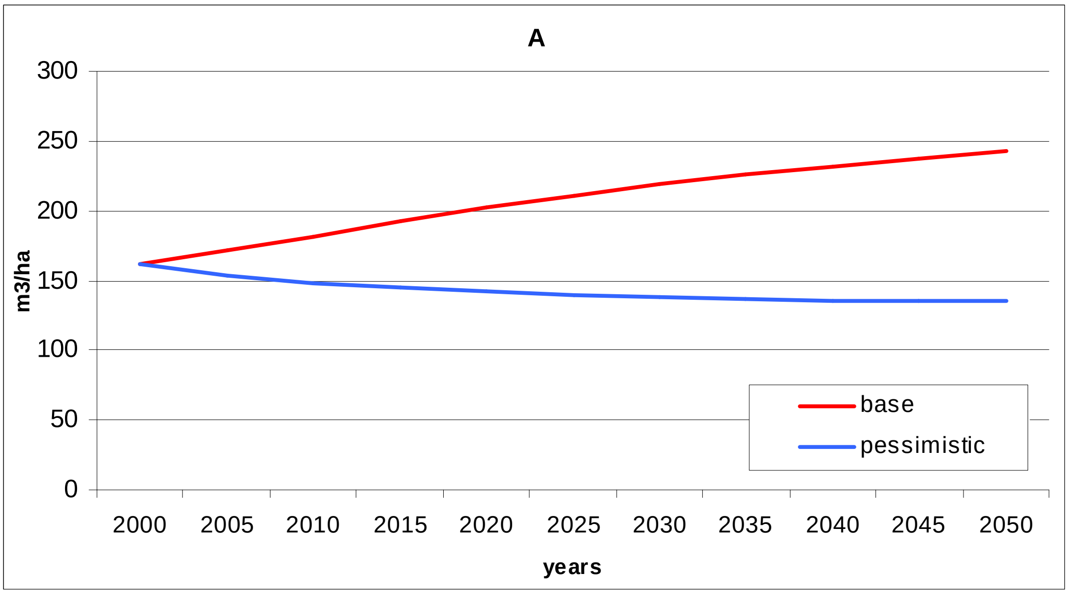

Fig. 5.Average volume per ha, total for the BG forests, based on EFISCEN simulation (2000-2050)(Kostov and Rafailova, 2008).

Removals and timber supply

The potential loss of timber supply, if the pessimistic scenario occur is up to 3,5 mln.m^3 annually (fig.6)

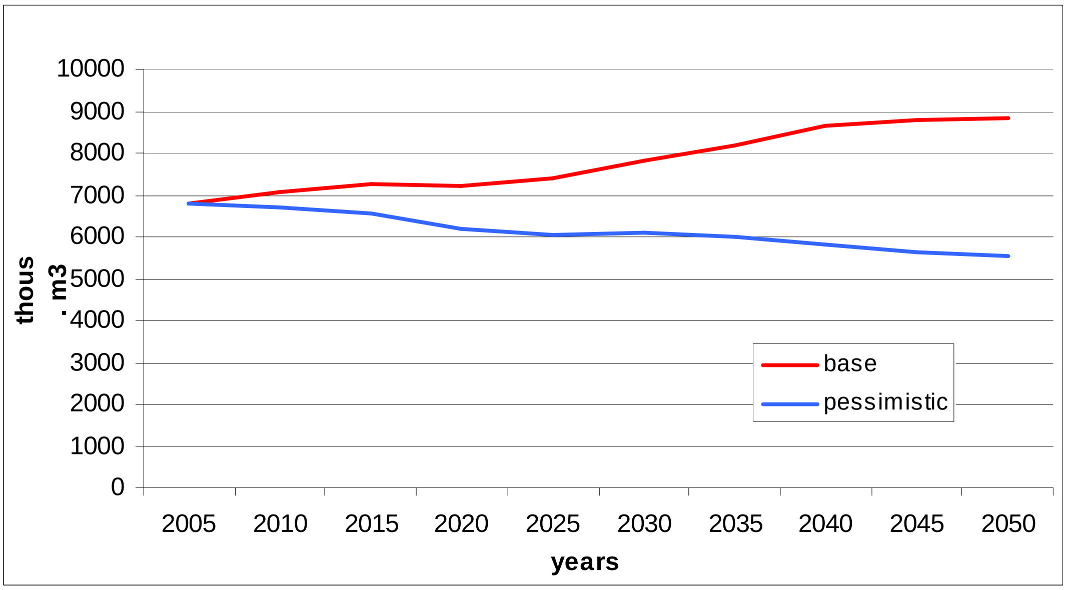

Fig. 6. Annual harvest (thinnings and fellings), total for the BG forests, based on EFISCEN simulation (2000-2050)(Kostov and Rafailova, 2008).

I.3. Impact monitoring

Two different monitoring programmes, concerned climate changes are running in Bulgaria.

The first one is more common called: "National Biomonitoring Program of Bulgaria" (Peev, Gerasimov, 1999). It is mainly oriented to the biomonitoring to the flora and fauna changes in Bulgarian national parks. The available data are property of Ministry of Environment and Water (MOEW).

The second one is called "Intensive monitoring of forest ecosystems in Bulgaria" (Kolarov at al. 2002). This is a preliminary report of the program started in 1994. The aim is to evaluate the impact of air pollution and other stress factors on forests. Parameters as meteorological data, air pollutants (SO x; NO x; O_3); air depositions; soils acidification; changes in plant communities and indicator species are observed. The methodology is based on International Co-operative Program "Assessment and monitoring of forest ecosystems- level II". At the present this program is going under the name "Assessment and monitoring of air pollution effects on forests" (MOEW 2006).

II. Adaptation

II.1. Vulnerability of forests and forestry

The territory of Bulgaria is located in two climate zones: European-continental and Continental-Mediterranean in which are distributed the following planet biomes: deciduous forests in the moderate zone, coniferous forests (taiga in the mountains), high-mountain forestless territories (tundra in the mountains) forest-steppes in the moderate zone, bushes and hard-leaved forests. Due to the mountain character of the country, on a relatively small territory of the Balkans, are distributed some altitudinal vegetation belts which reflect the horizontal zonality from the Mediterranean up to North Scandinavia.

Forest tree populations composed by perennial species are more vulnerable by climate changes than the agricultural crops which most frequently are annual as the forests occupy large territories sometimes on steep and rugged terrains during centuries. Then the probability to lead to strong changes is much more and the possibilities for fast response of a generation are limited. So the vulnerability of the forest tree populations is determined by their possibility for adequate changes in the structure and functioning in the existing area as well as by the possibilities for occupying new niches outside it. In sharp changes in the climate the forest tree populations are under strong stress and difficultly could express their adaptive potential.

The vulnerability of the forests in Bulgaria nowadays is more than 50 years ago and due to establishment of forest plantations especially outside their natural area. During the period 1955-2005 in the country was realized afforestation of about 1/3 from the forest territory. The massive dryings, especially of the coniferous plantations at altitude to 700 – 800 m, are due to their weaker adaptivity to water deficit because of anatomic peculiarities of the transport system (Raev, Rossnev, 2004).

The possibility for migration of the forest tree species to favorable for them niches or dying in more extreme climate changes are determined by the adaptive peculiarities heredited during their phylogenic development. The vulnerability of the forests depends also on the level of impeding of regeneration processes due to climate changes. The damages in the reproductive apparatus, in the processes of pollination, fecundation, maturation and dispersal of the seeds, lead to vulnerability of the forest populations. The enlargement of the areas damaged by diseases and pests aggravates their health status.

The vulnerability of forest ecosystems towards 2050 and especially in 2100 is expected to be more strongly expressed at the current tendency of climate changes.

If the scenario for increasing the level of oceans and seas due to glacier melting follows the current temps towards 2100 in Bulgaria there will be flooded some seaside and river bankside settlements as well as the longoz forests in North Bulgaria which are unique in Europe.

II. 2. General adaptation strategy or policy

In June 2000 the Council of Ministries of Bulgaria passed the National action plan on climate change which included an adaptation strategy in different sectors: agriculture, forestry, economy, etc.

The basic national forest documents which refer to climate change prevention are: 1) National strategy for forest protection and development of forestry in Republic of Bulgaria, 1996; 2) National forest policy and strategy (sustainable development of forest sector in Bulgaria 2003 – 2013) and 3) The strategic plan for the forest sector development 2007 – 2011.

The main priorities in these plans are in the following sequence:

In 1996

- Helping the adaptation of forests towards unfavorable climate changes;
- Conservation of biological diversity and of flora and fauna genetic resources at reproduction of forest resources.

In 2003

- Improvement in the stability and health status of forests including their capability for adaptation to climate conditions and pressure from anthropogenic activities.

In 2007

- Establishment and maintenance of vital forest ecosystems.

If the climate changes are in the direction of warming and drought, a considerable xerophytisation of the vegetation can be expected. The hydrophytes and some mesophytes will be strongly reduced. The vegetation will be concerned on a species and intraspecific level.

A strong reduction can be expected among the representatives of 32 local vegetation genera and 57 species.

This concerns as well the introduced forest tree and shrub species, as too sensitive to the expected climate changes are about 17 genera and 22 species.

The coming changes in the biodiversity will appear in reduction and fall off of the boreal forest species and increased participation of the species more resistant to drought and warming. Main role for conservation of the vegetation cover most probably will play these natural species which have the necessary morphological and physiological features to survive the new forest vegetation conditions. Such a resistance can be expected mainly from 18 families with forest tree and shrub species, 46 genera and 70 species.

In case of possible xerophytisation of the growth conditions, from the introduced species suitable could be the representatives of 21 families, 33 genera and 48 species.

Presumably the natural and introduced forest tree and shrub species in Bulgaria have a good capacity for adaptation to the eventual changes in the climate conditions during XXI century.

Besides these opportunities which could be determined as a potential on a ‘species level’ there are good possibilities for the biodiversity on ‘intraspecific level’. It means biodiversity on a level of subspecies, variety and form, strongly widening the adaptation at changes in the climate conditions. As bigger this adaptation potential, as more probable the surviving of the species. The composition and the structure of the forests in the country will depend on the scale of intraspecific diversity of the basic forest formations and on the speed of the formation processes.

Among the drought-resistant and thermofyllic autochthonous forest formations on which there is a research, a bigger adaptivity at the expected xerophytisation can show the taxons from 9 studied species: *Pinus nigra* Arn., *Quercus robur* L., *Quercus petraea* Liebl., *Quercus frainetto* Ten., *Quercus pubescens* Willd., *Quercus cerris* L., *Tilia tomentosa* Moenh., *Fraxinus ornus* L., *Corylus colurna* L.

II. 3. Forest adaptation measures

In realization of the National strategy on climate change and the consequenced from it national documents in the forest sector for adaptation of forests are elaborated some forest adaptation measures as follows:

1. Priority to natural regeneration. Tolerating the local tree and shrub species and giving priority to resistant species, provenances and genotypes.
2. Timely thinnings and tendings of forest stands in order to improve their health status and productivity of high quality and quantity timber. Intention to support of mixed, several stories, and different-aged stands. Improving the technologies for main fellings and intensive sanitary cuttings. Stopping the reconstruction of autochtonous forest stands.
3. Preferable harvesting of stands damaged by forest fires and climate impacts as windthrow, windbreak, snow uprooting, snowbreak, drought, frost, hailstorm, flooding, etc.
4. Realization of integral control with pests and diseases in forests. Establishment of forest pathology and entomology monitoring and comprehensive net of permanent sample plots.
5. Forest management planning to be realized on the base of multifunctional management of forest stands, of conservation of biological diversity in forests and their vitality.
6. Establishment and maintenance of forest infrastructure especially in stands with insufficient adaptive potential which are expected to suffer more from climate changes.
7. Maintaining of forest nursery production and choice of species for afforestation purposes till 700 – 800 m a.s.l. to be focused on broadleaves – predominantly oaks. As concerned to conifers – Austrian pine and Cedars to be used preferably in the dry sites.
8. It is necessary to establish forests in the plains via afforestation of lands unsuitable for agriculture. In the country they are about 250 000 ha uncultivated, eroded, salty and swampy lands.

   In the plains it is necessary creation of forest shelter belts on 50 000 ha in order to protect about 2 mill hectares arable land. The existing 10 000 ha forest shelter belts ensure especially effective protection of the agricultural crops in Dobrudzha – the granary of Bulgaria. This forest measure could be used as good agroforestry practice in other countries with similar natural conditions.

III. Mitigation

III.1 Carbon accounts and Kyoto protocol: data availability and current research studies

Bulgaria as a European Union member and a Party to Convention on Climate Change (UNFCCC), via decision of the European Parliament and European Council

(280/2004/EC), defined a mechanism for monitoring Community greenhouse gas emissions and for Kyoto Protocol implementation.

The National Inventory Reporting in the Land Use, Land-Use Change and Forestry (LULUCF) sector follows guidelines given in the Good Practice Guidance (GPG-LULUCF; IPCC 2003). However, until 2006 only data from above-ground biomass has been included. The lack of summarized data on the other components like soils, forest litter, dead biomass etc. was partially filled in 2007, when the Bulgarian State Forestry Agency (SFA) assigned the project "Preparation of Methodology for collection, analysis and verification of data from forests in the national GHG inventory" (SFA, 2007). The data collected presents a good basis for further development and additional studies in order to fulfil the gaps in greenhouse gas (GHG) reporting until 2010. The objectives for the reporting in the LULUCF sector under the UNFCCC are to monitor annual changes in emissions of (i) above ground biomass C pools, (ii) below ground biomass C pools, (iii) dead wood C pools, (iv) litter C pools, (v) soil C pools, and (vi) non-CO_2 greenhouse gases (GHGs), and arises the necessity of additional studies so that all units be analysed.

Reporting under the Kyoto Protocol requires monitoring of afforestation, reforestation and deforestation (IPCC, 2006; ARD, Article 3.3) and of possible additional human induced activities e.g. forest management (ARD, Article 3.4). Reporting for Article 3.3 requires monitoring of forest land conversion to/from other land use categories and monitoring of resulting changes in the carbon stocks. At present Bulgarian research centres participate in several monitoring networks, projects and research consortiums and have already produced information and knowledge about forest carbon sequestration. Nevertheless, the European forest monitoring network, established in 1986 by EC Regulation 3528/86 remains one of the main data sources. The quantities of CO2 emission/removals from forests for the GHGs inventory period 1988-2006 are presented in Table 2. CO2 removal is formed by the net balance of the atmosphere absorbed C and the volume of cut biomass (wood) used for heating, pulp production and other biomass consuming activities. The analysis of the CO2 removals trend shows a significant change for the period 1988–1991 in the range of 5100–7700 Gg, a relative stabilization during the period 1992–1995 at a level of about 7500 Gg, a drop in the year 1996 to 6500 Gg and a following steady tendency of increase until 2001. A drop follows after this period of steady increase due to increased felling. Information provided by national forest inventories (NFIs) carried out by the SFA concerns mainly the above-ground vegetation (Forest inventory in the country is not fully based on permanent sample plots). Information on C in soils, forest litter and dead wood biomass, as well as on belowground C pool have not been included yet. Studies related to mitigation include: investigation on organic matter in forest and mountainous soils in Bulgaria (Artinova, 1978), determining the organic matter content changes in soils affected by forest fires (Velizarova et al., 2003), defining the effects of forest-related land-use changes on carbon storage in forest soils (Zhiyanski et al., 2008a), etc.

Table 2. Quantities of CO_2 emission/removals (Gg) from forests for the GHGs inventory period 1988-2006 (MEW, 2008).

Year	Carbon uptake increment	Carbon release	Carbon net uptake	Net CO_2 removals
1988	2761.0	-1361.2	1399.8	-5132.6
1989	2861.5	-1326.2	1535.3	-5629.3
1990	2961.9	-1282.7	1679.2	-6157.0
1991	3062.3	-979.9	2082.5	-7635.7
1992	3162.8	-1141.3	2021.5	-7412.0
1993	3263.2	-1224.4	2038.8	-7475.8
1994	3321.0	-1329.6	1991.4	-7301.7
1995	3361.5	-1309.4	2052.1	-7524.5
1996	3361.5	-1584.0	1777.5	-6517.5
1997	3361.5	-1487.4	1874.1	-6871.5
1998	3361.5	-1490.5	1871.0	-6860.5
1999	3361.5	-1397.9	1963.6	-7199.8
2000	3697.7	-1249.6	2448.1	-8976.2
2001	3697.7	-1115.7	2581.9	-9467.1
2002	3697.7	-1429.1	2268.6	-8318.1
2003	3697.7	-1773.3	1924.4	-7056.0
2004	4110.4	-1938.1	2172.3	-7965.2
2005	3812.5	-1904.4	1908.0	-6996.0
2006	3812.5	-1904.4	1908.0	-6996.0

III. 2 Forests as carbon sink: potential, bio-energy production and measures for improved forest management

Data about distribution of Bulgarian forests area based on detailed inventory was announced as late as 60^s of the last century. In 1965 total forested area was estimated at 3.05 mill ha or 28% of country's territory (Subev et al., 1993). Through years these values gradually increased – up to 3.72 mill. ha and 33.5% respectively in 2008 (SFA, 2008). It is predominately a result of the intense afforestations in the period 60^s–80^s of the last century: the current area of forest plantations in Bulgaria is 0.813 mill. ha (SFA, 2008).

The total growing stock of Bulgarian forests is estimated at above 600 mill. m^3 (SFA, 2008). There is a potential for total growing stock future increase but also possibilities for decrease due to negative tendencies in the economic situation (e.g. lack of investments for additional afforestation) as well as the negative effect of disturbances caused by climate change – low level of stability of young forests, higher and earlier mortality for the mature ones, inadequate natural regeneration etc (pessimistic scenario). Comparison between different forest ecosystems development scenarios could suggest some general understanding for forests carbon sequestration potential (Table 3).

Table 3. Forests carbon sequestration dynamics based on EFISCEN simulation (2000-2050)

Year	Carbon sequestration			
	Total (Tons)	Total (incl. dead wood) (Tons)	Thinnings (Tons)	Final harvest cuts (Tons)
Base scenario				
2005	156739	235754	3892	4623
2010	165779	236001	4087	4789
2015	174520	236263	4158	4995
2020	183301	236544	3633	5460
2025	191763	236845	3451	5849
2030	198962	237163	3642	6212
2035	205321	237497	3729	6574
2040	210820	237841	3935	6937
2045	216209	238194	4084	6858
2050	221495	238568	4106	6815
Pessimistic scenario				
2005	139494	13166114	3892	4623
2010	133766	13177434	3892	4537
2015	129713	13187402	3811	4456
2020	126630	13196760	3247	4602
2025	124115	13205651	2954	4664
2030	121473	13214027	3077	4654
2035	119389	13221874	3071	4521
2040	118224	13229184	3171	4132
2045	117950	13236119	3226	3767
2050	118067	13242856	3304	3551

According to Velichkov et al. (in press) Bulgaria has not still developed a functioning industry for energy production from renewable sources such as wood, wooden residua etc. Since 1990 the usage of firewood has been expanding. About 3.33 mill. m^3 were used as firewood in 2008 (SFA, 2008).

Improving the potential of Bulgarian forests to reduce part of the greenhouse problem by more efficient carbon sequestration would require improved forest management. The later should also consider abovementioned forest adaptation measures and include:

– Increasing the roundwood and biomass production. It has been estimated that it is silviculturally sounded that 4.3 m^3 of roundwood is yearly obtained by Bulgarian State and private forests from thinnings (Kostov and Rafailova, 2009). Species which are characterized by significant potential to increase the wood production from thinnings are Pinus nigra, Pinus silvestris, Fagus sp., Quercus sp., Carpinus betulus, Tilia sp., etc.;

– More efficient management of coppice forests – increasing the roundwood and biomass production from both thinnings and final harvest cuts, and gradual transformation of coppice forests into seed ones;

– Promotion of silvicultural measures to establish mixed and uneven-aged stands on appropriate sites;

– Partial afforestation of abandoned pasture and agricultural land.

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