

## 1. Forest resources and forestry

The total forest land in the Republic of Macedonia is 11,596km<sup>2</sup> (1,159,600ha) out of which forests are 947,653ha<sup>1</sup>. The total wood mass is **74,343,000m<sup>3</sup>**, and the total annual increment is **1,830,000m<sup>3</sup>** with average annual increment of 2.02m<sup>3</sup> per hectare.

With the help of the Aforestation Fund (that was active until 1990) more than 140,000 ha of bare lands were planted and an increment was achieved of afforestation with index an index 1.6.

About **90.14%** of the total area is state owned forest, while their part of the total wood mass is **92.2%**. Private owned forests are **9.86%** (94146ha)<sup>2</sup> of the total forest area, and their portion of the total wood mass is **7.8%**.

Out of the total forest and forest land area, 8% are not planned.

Forestry in Macedonia is an economy branch that participates in the Gross National Product with 0.3 - 0.5%, but if the multifunctional uses were to be valorized, the contribution would be bigger.

The planned annual available cut<sup>3</sup> in the Republic in Macedonia in the last 10 years is about 1,300,000m<sup>3</sup>, out of which around 70% are utilized. From the produced special forest products, 80 to 85% is firewood.

Forests in the Republic of Macedonia are characterized with a rich biodiversity. Macedonia has significant non-timber forest resources: medical plants, mushrooms, forest fruits, game, etc. The importance of forests is emphasized by the fact that the main part of the territory of the protected areas in this country are under forest.

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<sup>1</sup> Statistical review: Agriculture, 5.4.5.03 504 Forestry, 1997-2004, State Statistical Office of the Republic of Macedonia

<sup>2</sup> Statistical Yearbook of the Republic of Macedonia 2004, (10.01, Forestry), State Statistical Office of the Republic of Macedonia

<sup>3</sup> **annual available cut** - the planned and allowable rate of timber harvest from a specified area of land in accordance to the forestry management plans.

Some of the main threats and problems in forest management and governance are: illegal logging that takes huge proportions, other illegal activities, forest fires which have affected nearly 100 000 ha for the last 10 years, climate changes through the forests dieback process, insect calamities<sup>4</sup> and diseases. All these lead to enormous economic and environmental losses to the sector.

## **2. Climate change impacts on forest health condition**

As it was mentioned before, on the health situation of the forest and on working activities in forestry climate conditions have a big role. Forestry, by its characteristics, is closely connected with working on open space and very often, beyond other things, good or bad economic results in the sector depend on actual weather conditions, but also from long-term climate. To find out the influence of climate changes on forests and forestry we will analyze the period 1990 - 2005.

The period from 1990 until 2000 was analyzed in Macedonian's first national communication under the United Nations framework convention on climate change (2003) and these results will serve us for comparison with the following period, enabling us to evaluate and analyze a period of 16 years.

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<sup>4</sup> **calamities** - damages

## ***2.1. Assessment of certain morphological changes on the oak and fir***

For monitoring and assessment of the health conditions of forests, with ICP Forests methodology, a number of parameters are considered which should to be checked and evaluated.

Faced with growing concern about forest condition in Europe in 1985 the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on forests (ICP Forests) has been established by the UN/ECE under the Convention on Long-range Transboundary Air Pollution (CLRTAP). Since then, ICP Forests and EU have been monitoring forest condition in close cooperation. Today, 40 countries (including Macedonia from this year) including all EU-Member State, Canada and USA are participating.

The ICP Forests mandate is:

- To monitor effects of anthropogenic factors (in particular air pollution) and natural stress factors (climate changes, insects, fungi etc), on the condition and development of forest ecosystems in Europe, and
- To contribute to better understanding of cause-effect relationships in forest ecosystems functioning in various parts of Europe.

Based on its mandate, ICP Forests pursues the following (beyond the others) objectives:

- To provide a periodic overview on spatial and temporal variation in forest condition in relation to anthropogenic as well as natural stress factors on an European and national large systemic network (about 5700 monitoring plots in Europe) (Level I);
- To contribute by means of the monitoring activities to other aspects of relevance for forest policy at national, pan-European and global level, such as effects of climate changes on forests, sustainable forest management and biodiversity in forests.

Apart from site description and type of phytocenosis, other very important data are: crown transparency, dieback of certain parts of the crown and whole trees, discoloration of assimilatory parts (needles/leaves), mechanical damages on the trunk and so on. Because of the importance and specifics of some of these parameters, we have chosen them as indicators for following the development of the dieback process and the influence of climate change on oak and fir forests in our country, and these results can be compared with those from other countries in Europe.

One of the parameters that gives us a picture of the influence of climate changes on health condition of trees/forests are: crown transparency and dieback of certain parts of the crown and whole trees, with which in a best way can be followed the morphological changes from the dieback process of the trees.

For that purpose, 7 (seven) sample plots are established (3 sample plots in oak and 4 sample plots on fir forests):

1. S.P. "Ograzden" – Strumica region, oak forest
2. S.P. "Manastirska suma" – Kicevo region, oak forest
3. S.P. "Klinski livadi" – Kavadarci region, oak forest
4. S.P. " Lesnicks reka" – Kavadarci region, fir forest

5. S.P. "Turska cesma" – Bitola region, fir forest
6. S.P. "Brajcino" – Resen region, fir forest
7. S.P. "Gorna Radika" – Mavrovo region

Sample plots on oak are established in ass. *Orno-Quercetum petrae* **Em.** from 670 m to 1140 m above sea level, and for fir in ass. *Abieti-fagetum macedonicum* **Em.** from 1400 to 1600 m above sea level. In both cases, the differences from sea level give us an opportunity to get a clear picture of the influence of climate changes on health condition of the oak and fir.

On these sample plots monitoring activities are conducted every three years, from 1990 until the present.

### 2.1.1 Crown transparency

This parameter is evaluated with the loss of foliar mass of the tree. For more precise evaluation of this parameter, and for others a Guide by the Forestry Commission-Field Book 12 (1990 year), is published in an updated version from 2004, in which with examples and pictures are precisely described on methods for the evaluation and the assessment of the all parameters. We used the mentioned Guides in our assessments.

Visual assessment of the crown transparency is done in five classes, which are:

Class	Scale of loss of needles/leaves	Percentage of loss of needles/leaves
0	no loss of n/l	from 0 – 10 %
1	small loss of n/l	>10 < 25 %
2	moderate loss of n/l	>25 < 60 %
3	high loss of n/l	> 60 %
4	dead tree	100 %



Picture number 1: Crown transparency of fir – S.P. "Gorna Radika"

## Crown transparency in sample plots under oak forests

Table 1

<b>CROWN TRANSPARENCY - %</b>					
<b>1991 year</b>					
Classes of crown transparence					
Sample plots	0	1	2	3	4
Ograzden	82,7	11,9	4,8	0,6	0
Manastirska suma	73,9	18,5	3,1	1,4	2,8
Klinski Livadi	72,4	21,6	4,9	1,1	0
<b>Average:</b>	<b>76,4</b>	<b>17,4</b>	<b>4,3</b>	<b>1,0</b>	<b>0,9</b>
<b>1993 year</b>					
Ograzden	96,1	2,5	1,3	0	0
Manastirska suma	93,3	1,7	0	0	4,6
Klinski Livadi	52,4	35,7	9,2	1,1	1,6
<b>Average:</b>	<b>80,6</b>	<b>13,4</b>	<b>3,5</b>	<b>0,4</b>	<b>2,1</b>
<b>1994 year</b>					
Ograzden	94,0	3,7	2,3	0	0
Manastirska suma	27,1	50,9	12,2	0,7	8,4
Klinski Livadi	51,2	35,8	6,8	1,3	4,9
<b>Average:</b>	<b>57,5</b>	<b>30,2</b>	<b>7,2</b>	<b>0,6</b>	<b>4,5</b>
<b>1996 year</b>					
Ograzden	74,3	9,5	12,5	2,2	1,5
Manastirska suma	27,1	48,2	14,3	1,7	8,7
Klinski Livadi	49,2	35,5	8,2	1,6	5,5
<b>Average:</b>	<b>50,2</b>	<b>31,1</b>	<b>11,7</b>	<b>1,8</b>	<b>5,2</b>
<b>1999 year</b>					
Ograzden	71,1	10,9	13,3	2,9	1,8
Manastirska suma	27,0	46,6	15,4	2,0	9,0
Klinski Livadi	49,0	34,9	8,5	2,2	5,4
<b>Average:</b>	<b>49,0</b>	<b>30,8</b>	<b>12,4</b>	<b>2,4</b>	<b>5,4</b>
<b>2003 year</b>					
Ograzden	78,8	10,1	8,1	1,2	1,8
Manastirska suma	32,5	48,2	9,3	1,0	9,0
Klinski Livadi	58,9	30,6	3,8	1,3	5,4
<b>Average:</b>	<b>56,7</b>	<b>29,6</b>	<b>7,1</b>	<b>1,2</b>	<b>5,4</b>
<b>2006 year</b>					
Ograzden	79,0	17,5	1,0	0,7	1,8
Manastirska suma	45,1	40,3	4,6	1,0	9,0
Klinski Livadi	65,8	27,2	1,1	0,5	5,4
<b>Average:</b>	<b>63,3</b>	<b>28,4</b>	<b>2,2</b>	<b>0,7</b>	<b>5,4</b>

## Crown transparency in sample plots of fir forests

Table 2

<b>CROWN TRANSPARENCY - %</b>					
<b>1991 year</b>					
Classes of crown transparency					
Sample plots	0	1	2	3	4
Lesnicka Reka	53,8	26,6	18,9	0,7	0
Turska cesma	42,4	21,9	18,9	3,9	12,9
Brajcino	60,6	31,3	8,1	0	0
Gorna Radika	90,6	9,4	0	0	0
<b>Average:</b>	<b>61,8</b>	<b>22,3</b>	<b>11,6</b>	<b>1,1</b>	<b>3,2</b>
<b>1993 year</b>					
Lesnicka Reka	73,4	18,2	8,4	0	0
Turska cesma	46,2	18,2	18,2	3,8	13,6
Brajcino	79,8	16,2	3,0	0	0
Gorna Radika	79,1	20,9	0	0	0
<b>Average:</b>	<b>69,6</b>	<b>18,5</b>	<b>7,5</b>	<b>1,0</b>	<b>3,4</b>
<b>1994 year</b>					
Lesnicka Reka	94,7	5,3	0	0	0
Turska cesma	67,4	14,8	3,7	1,5	12,6
Brajcino	95,0	2,0	1,0	0	2,0
Gorna Radika	96,2	3,8	0	0	0
<b>Average:</b>	<b>88,3</b>	<b>6,5</b>	<b>1,2</b>	<b>0,4</b>	<b>3,6</b>
<b>1996 year</b>					
Lesnicka Reka	94,0	5,3	0,7	0	0
Turska cesma	67,4	14,2	4,4	0,7	13,3
Brajcino	92,0	4,0	2,0	0	2,0
Gorna Radika	95,4	4,6	0	0	0
<b>Average:</b>	<b>87,2</b>	<b>7,0</b>	<b>1,8</b>	<b>0,2</b>	<b>3,8</b>
<b>1999 year</b>					
Lesnicka Reka	93,0	5,0	0,5	1,0	0,5
Turska cesma	67,0	13,8	4,2	1,7	13,3
Brajcino	91,0	2,3	1,3	0	5,4
Gorna Radika	95,0	4,2	0,2	0,6	0
<b>Average:</b>	<b>86,5</b>	<b>6,3</b>	<b>1,6</b>	<b>0,8</b>	<b>4,8</b>
<b>2003 year</b>					
Lesnicka Reka	94,0	4,5	0,5	0,5	0,5
Turska cesma	70,0	12,5	3,3	0,9	13,3
Brajcino	91,0	2,5	1,1	0	5,4
Gorna Radika	95,5	4,0	0,2	0,3	0
<b>Average:</b>	<b>87,6</b>	<b>5,9</b>	<b>1,3</b>	<b>0,4</b>	<b>4,8</b>
<b>2006 year</b>					
Lesnicka Reka	95,1	3,6	0,5	0,3	0,5
Turska cesma	76,3	7,7	2,0	0,7	13,3
Brajcino	92,0	2,4	0,2	0	5,4
Gorna Radika	95,6	4,0	0,3	0,1	0
<b>Average:</b>	<b>89,8</b>	<b>4,4</b>	<b>0,7</b>	<b>0,3</b>	<b>4,8</b>

### 2.1.2 Dieback of parts of the crown or of whole trees

With the assessment of this parameter the percentage of died parts-branches in crown on certain tree are expressed. This parameter is also in five classes:

Class	Scale of died parts-branches	Percentage of died parts-branches
0	no died parts-branches	from 0 – 10 %
1	small amount of died parts-branches	>10 < 25 %
2	moderate amount of died parts-branches	>25 < 60 %
3	high amount of died parts-branches	> 60 %
4	dead tree	100 %

The data for this parameter (dieback), for the sample plots of oak forests, are given in Table 3, and for sample plots of fir forests in Table 4.



Picture number2: Dieback of parts of the crown or whole trees – S.P. "Turska cesma"

## Dieback of parts of the crown or whole trees in sample plots of oak forest

Table 3

<b>DIEBACK - %</b>					
<b>1991 year</b>					
Classes of dieback					
Sample plots	0	1	2	3	4
Ograzden	99,4	0	0,6	0	0
Manastirska suma	52,9	35,9	6,9	1,5	2,8
Klinski Livadi	87,6	11,4	0,5	0,5	0
<b>Average:</b>	<b>80,0</b>	<b>15,8</b>	<b>2,7</b>	<b>0,6</b>	<b>0,9</b>
<b>1993 year</b>					
Ograzden	48,4	31,8	16,6	3,2	0
Manastirska suma	23,4	52,9	16,7	2,4	4,6
Klinski Livadi	24,3	55,2	17,8	1,1	1,6
<b>Average:</b>	<b>32,0</b>	<b>46,6</b>	<b>17,1</b>	<b>2,2</b>	<b>2,1</b>
<b>1994 year</b>					
Ograzden	46,6	32,9	17,0	3,5	0
Manastirska suma	27,4	50,9	12,5	0,8	8,4
Klinski Livadi	34,5	35,0	24,0	1,6	4,9
<b>Average:</b>	<b>36,1</b>	<b>39,6</b>	<b>17,8</b>	<b>2,0</b>	<b>4,5</b>
<b>1996 year</b>					
Ograzden	44,1	37,4	11,1	5,9	1,5
Manastirska suma	8,7	30,3	48,8	3,5	8,7
Klinski Livadi	32,2	35,5	24,6	2,2	5,5
<b>Average:</b>	<b>28,3</b>	<b>34,4</b>	<b>28,2</b>	<b>3,9</b>	<b>5,2</b>
<b>1999 year</b>					
Ograzden	44,0	35,6	14,0	4,6	1,8
Manastirska suma	8,7	34,7	45,6	2,0	9,0
Klinski Livadi	31,0	47,2	14,2	2,2	5,4
<b>Average:</b>	<b>27,9</b>	<b>39,2</b>	<b>24,6</b>	<b>2,9</b>	<b>5,4</b>
<b>2003 year</b>					
Ograzden	48,4	35,1	11,2	3,5	1,8
Manastirska suma	10,7	45,6	32,7	2,0	9,0
Klinski Livadi	33,3	50,1	9,1	2,1	5,4
<b>Average:</b>	<b>30,8</b>	<b>43,6</b>	<b>17,7</b>	<b>2,5</b>	<b>5,4</b>
<b>2006 year</b>					
Ograzden	48,0	35,2	11,5	3,5	1,8
Manastirska suma	10,4	46,2	32,4	2,0	9,0
Klinski Livadi	33,6	51,3	7,5	2,2	5,4
<b>Average:</b>	<b>30,7</b>	<b>44,2</b>	<b>17,1</b>	<b>2,6</b>	<b>5,4</b>

## Dieback of parts of the crown or whole trees in sample plots of fir forest

Table 4

<b>DIEBACK - %</b>					
<b>1991 year</b>					
	Classes of dieback				
Sample plots	0	1	2	3	4
Lesnicka Reka	61,4	21,2	17,4	0	0
Turska cesma	81,8	4,6	0,7	0	12,9
Brajcino	100,0	0	0	0	0
Gorna Radika	97,1	2,9	0	0	0
<b>Average:</b>	<b>85,1</b>	<b>7,2</b>	<b>4,5</b>	<b>0</b>	<b>3,2</b>
<b>1993 year</b>					
Lesnicka Reka	83,3	14,4	2,3	0	0
Turska cesma	72,7	12,3	0,7	0,7	13,6
Brajcino	79,8	18,2	2,0	0	0
Gorna Radika	92,1	7,9	0	0	0
<b>Average:</b>	<b>82,0</b>	<b>13,2</b>	<b>1,2</b>	<b>0,2</b>	<b>3,4</b>
<b>1994 year</b>					
Lesnicka Reka	93,2	6,0	0,8	0	0
Turska cesma	54,8	25,9	3,7	3,0	12,6
Brajcino	92,0	4,0	2,0	0	2,0
Gorna Radika	94,6	5,4	0	0	0
<b>Average:</b>	<b>83,6</b>	<b>10,3</b>	<b>1,7</b>	<b>0,8</b>	<b>3,6</b>
<b>1996 year</b>					
Lesnicka Reka	93,2	5,3	1,5	0	0
Turska cesma	53,3	25,3	5,9	2,2	13,3
Brajcino	90,0	4,0	3,0	1,0	2,0
Gorna Radika	93,9	6,1	0	0	0
<b>Average:</b>	<b>82,6</b>	<b>10,2</b>	<b>2,6</b>	<b>0,8</b>	<b>3,8</b>
<b>1999 year</b>					
Lesnicka Reka	93,2	5,4	0,6	0,3	0,5
Turska cesma	52,1	24,3	6,7	3,6	13,3
Brajcino	86,6	5,0	2,0	1,0	5,4
Gorna Radika	93,9	4,0	1,5	0,6	0
<b>Average:</b>	<b>81,4</b>	<b>9,7</b>	<b>2,7</b>	<b>1,4</b>	<b>4,8</b>
<b>2003 year</b>					
Lesnicka Reka	93,3	5,6	0,6	0	0,5
Turska cesma	55,5	27,1	3,2	0,9	13,3
Brajcino	88,0	5,3	1,0	0,3	5,4
Gorna Radika	94,5	3,7	1,4	0,4	0
<b>Average:</b>	<b>82,8</b>	<b>10,4</b>	<b>1,6</b>	<b>0,4</b>	<b>4,8</b>
<b>2006 year</b>					
Lesnicka Reka	93,4	5,5	0,6	0	0,5
Turska cesma	57,8	25,0	3,1	0,8	13,3
Brajcino	89,1	4,2	1,0	0,3	5,4
Gorna Radika	94,6	3,6	1,4	0,4	0
<b>Average:</b>	<b>83,7</b>	<b>9,6</b>	<b>1,5</b>	<b>0,4</b>	<b>4,8</b>

## Oak trees with died top of the crown

Table 5

Died top of the tree crown - %							
Sample plots	1991	1993	1994	1996	1999	2003	2006
Ograzden	6,8	18,6	26,5	30,1	30,0	29,3	27,6
Manastirska suma	7,7	17,4	28,9	32,0	32,0	31,0	27,3
Klinski Livadi	7,1	31,1	32,8	34,4	34,0	32,8	28,5
<b>Average:</b>	<b>7,2</b>	<b>22,4</b>	<b>29,4</b>	<b>32,2</b>	<b>32,0</b>	<b>31,0</b>	<b>27,8</b>

By the analyses of data, for both crown transparence and dieback (Table 1, 2, 3 and 4), it can be concluded:

The health condition, both in oak and fir, in the period 1991-1999 was getting considerably worse. On the other side, in the period 2000-2003, better health conditions were assessed for both oak and fir, .

The analysis in the First Report, for the period from 1991 - 2000 has shown that the worsening of the health condition of the oak and fir are as a consequence of high air temperatures and drastically low precipitations during that period.

Performing the same type of analysis for the period 2001 - 2005 we can conclude that climate characteristics in this period had positive influence on health condition of the oak and fir.

For example, the total sum of precipitations in Mavrovo for the period 1991-2001 year was 9 568,6 mm, and for the period 2002-2005 it was 4 795,6 mm. That means that in the period 1991-2001 the average annual sum of precipitations was 869,8, and for the period 2002-2005 it was 1 198,9 mm. The difference is a full 329,1 mm of precipitation per year. In Strumica, average annual sum of precipitations for the period 1991-2001 was 512,7 mm, and for the period 2002-2005 it was 691,1 mm. The difference is 178,4 mm of precipitation per year. Similar is the condition in the Bitola region, where in the period 1991-2001 the average annual sum of precipitations was 572,1 mm, and in the period 2002-2005 year it was 705,9 mm. The difference is 133,8 mm of precipitations per year.

According to data for average monthly and average annual air temperatures for the periods 1991-2000 and 2001-2005, there is a small rise of the average annual temperatures. For example, in the Bitola region, average annual air temperature for the period 1991-2000 was

11,3°C, while for the period from 2001 to 2005 it was 11,5 °C. In the Strumica region, average annual air temperature in the period 1991-2000 year was 12,7 °C, and in the period from 2001 - 2005 it was 13,3 °C.

When the air temperature and the sum of precipitations were put into correlation, we came to a conclusion that in the period 2001-2005 year forest plants species in the Republic of Macedonia have had very good conditions for their vegetation and growth. Because of this, through the assessment for dieback and crown transparency of oak and fir we saw positive development of their health condition.

With the last field's data for year 2006, it is shown that health condition of oak and fir is still getting better. At fir, this is more expressed i.e. percentage of trees without signs of crown transparency in year 2003 amounted 87,6 % and in year 2006 89,8 %. At oak this percentage in year 2003 has been 56,7% and in year 2006 63,3 %.

Assessment of the symptom of dieback of parts of crown or whole trees in year 2006 shows that this process is in stagnation i.e. neither some significant positive or negative development occurred. Percentage of fir trees that do not show signs of this symptom in year 2003 amounted 82,8 % and in year 2006 83,7 %, and at oak trees in year 2003 amounted 30,8 % and in year 2006 30,7 %.

Percentage of oak trees that have dead top of the crown in year 1999 has been 32,0 %, in year 2003 it has been 31,1 % and in year 2006 it is 27,8 %. From this symptom, combined with previous two, it is seen that water supply of the crown of oak trees is improved. It has been happened due to increased precipitations in the last five years (during the vegetation period and out of it).

## ***2.2. Forest fires***

Forest fires, at the moment, are one of the most negative factors in Europe and the globally, which have influence in decrement of the forest areas and their health condition. There are several factors which affect appearance of forest fires, their duration and the size of the burned areas. Among the most important factors, often decisive, are the weather conditions, more precisely the climate characteristics of the region. Because of this mutual connection of climate

and forest fires and consequences from them, analyses have been made for forest fires in the Republic of Macedonia for the period 1989 to 2005 (Table 6, 7 and 8).

As with the analyses for dieback and crown transparence, with this analysis we can also clearly distinguish the periods 1989-2000 and 2001-2005.

The average annual number of forest fires for the period 1989-2000 was 272,7 fires, and during 2001-2005 that number was 90,2 fires annually. This is a significant difference between the two periods, also visible in the burned area. In the period 1989-2000 the average annual burned area was 6 994,0 ha, while for the period 2001-2005 year it was 3 372,6 ha.

In both cases, climate changes play a decisive role. In Chapter 2.1 we explained which the differences of these periods are.

The situation with fires is better understood with the analyses of the absolute maximums of air temperature in July (1991-2005). The absolute maximum of air temperature in July in the Bitola region was 39,3 °C (in 2000), and in the period 2001-2005 it was 36,7 °C in 2005. The absolute maximum of air temperature in the Gevgelija region was 44,6 °C (in 2000), and for the period 2001-2005 it was 40,3 °C in 2002. In the Mavrovo region it was 32,2 °C (2000), and in the period 2001-2005 it was 30,3 °C in 2003. The condition is similar in the Strumica region where absolute maximum of the air temperature in July was 40,8 °C (2000), and in the period 2001-2005 it was 30,3 in the year 2003.

**Number of forest fires for the period from 1989 to 2005 ( Source:MIA)**

Table 6

Land Use	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Average
Deciduas	33	65	9	57	111	68	9	15	26	26	256	395	58	26	25	22	13	1 214	71,4
Coniferous	11	43	6	32	50	23	3	18	36	20	34	133	26	5	22	22	18	502	29,5
Mixed	31	73	11	98	141	65	9	40	78	73	82	454	60	21	41	26	20	1323	77,8
Shrub forests	9	37	4	26	43	14	0	5	10	11	-	-	7	4	0	1	1	172	10,1
Other	11	23	8	22	45	25	3	12	24	21	80	205	14	3	8	2	6	512	30,1
<b>Total-forests</b>	<b>95</b>	<b>241</b>	<b>38</b>	<b>235</b>	<b>390</b>	<b>195</b>	<b>24</b>	<b>90</b>	<b>174</b>	<b>151</b>	<b>452</b>	<b>1187</b>	<b>165</b>	<b>59</b>	<b>96</b>	<b>73</b>	<b>58</b>	<b>3723</b>	<b>218,9</b>

**Burned area for the period from 1989 to 2005 ( Source:MIA)**

Table 7

Land Use	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Average
Deciduas	172,2	1987,6	49,5	904,4	6034,3	1486,3	47,5	54,3	271,0	160,9	1062,2	16182,9	2468,7	472,3	491,7	890,00	766,5	33 502,3	1 970,7
Coniferous	40,5	1260,6	5,7	208,2	1368,2	2523,1	1,3	100,6	1299,7	156,7	332,1	1660,5	1007,7	5,2	115,6	92,87	227,1	10 405,67	612,1
Mixed	118,8	876,4	35,9	7632,9	4446,8	1471,8	5,4	429,8	652,7	1282,1	343,2	17345,4	2888,6	111,1	3025,8	589,18	2985,7	44 241,58	2 602,44
Shrub forests	1258,8	1214,0	345,0	359,6	462,9	174,3	0,0	85,0	1138,3	21,5	0,0	0,0	77,5	44,5	0,0	1,50	1,0	5 183,9	304,9
Other	43,1	421,8	7,7	285,1	2111,6	146,2	51,2	316,4	212,1	268,0	254,5	2739,7	224,3	26,0	303,2	10,50	36,3	7 457,7	438,7
<b>Total-forests</b>	<b>1633,4</b>	<b>5760,4</b>	<b>443,8</b>	<b>9390,2</b>	<b>14423,8</b>	<b>5801,7</b>	<b>105,4</b>	<b>986,1</b>	<b>3573,8</b>	<b>1889,2</b>	<b>1992,0</b>	<b>37928,5</b>	<b>6666,8</b>	<b>659,1</b>	<b>3936,3</b>	<b>1584,05</b>	<b>4016,6</b>	<b>100 791,15</b>	<b>5 928,89</b>

Number of forest fires, burnt area (ha), burnt timber mass (m<sup>3</sup>) and economic losses (euros)

Source:P.E. " Macedonian forests" (1999-2005)

Table 8

Year	Number of fires	Burnt area (ha)	Burnt timber mass (m <sup>3</sup> )	Extinguishing fees (euro)	Total fees (euro)
1999	69	2 414,80	1 950,0	32 512,00	372 921,00
2000	476	46 235,73	711 782,00	976 142,00	15 642 775,00
2001	161	6 263,30	88 260,00	66 810,81	9 851 849,00
2002	65	1 186,30	24 661,28	15 193,10	298 902,00
2003	144	1 068,88	10 987,00	44 607,87	251 527,00
2004	94	892,05	4 322,30	23 214,55	1 469 090,00
2005	182	1 368,00	1 063,00	42 018, 11	411 181,10
<b>Total</b>	<b>1 191</b>	<b>59 429,06</b>	<b>843 025,58</b>	<b>1 200 498,36</b>	<b>28 298 245,10</b>
<i>Average</i>	<i>170</i>	<i>8 489,86</i>	<i>120 432,22</i>	<i>171 499,76</i>	<i>4 042 606,44</i>

### **3. Influence of climate changes on forestry and forest management**

Climate characteristics in the period 2001-2005, in relation with forest fires, had reflected well not just in the number of fires but also in the size of burned area. From data in Table 8 for forest fires we can conclude that there is direct impact on the economical situation of the P.E. "Macedonian forests"-Skopje, which manages forests in Macedonia. The total amount of economical losses due to forest fires in the period 1999-2005 was 28 298 245,10 €, of which only in the year 2000 the damage was 15 642 775,00 €. The situation is similar in 2001, but not because of large number of forest fires and climatic conditions, but due to improper extinguishing interventions of some fires. In the following years we have drastically decreased damages from forest fires mainly because of the unfavorable climate conditions for their appearance and spread. More precisely, the higher sum of the precipitations during the whole year and the green vegetation in the summer months as a result of the good conditions for its growth had a crucial role in this.

For comparison of the damages from forest fires, we will give the data that annual incomes of the P.E. "Macedonian forests" are approximately 30 000 000, 00 €.

The good climate conditions in the period 2001-2005 had not only positive effects on the health condition of forests and on forests fires. During this period, the appearance and gathering of mushrooms in the forests in Macedonia was significant. Except revenues in forestry from cutting and selling of wood (fuel wood and timber) there is a significant role for "non wood" products (mushrooms, medical plants, eteric oils etc). The effects in economical working of P.E. "Macedonian forests" mainly come from permits issued for collection and gathering of mushrooms to private firms for certain money compensation. Also, that directly affects the economic situation of the local community, which is largely committed to gathering and sale of mushrooms to collection centers.

Additional analyses are needed in order to evaluate the exact economical effects of gathering and sale of mushrooms in the local community and P.E."Macedonoan forests". However there is the problem of nonexistence of a quality database for the quantity of the purchased and exported mushrooms. The purchase prices depend on the period of the year, quality of the mushrooms and the species, and ranges from 3,5 to 10 €/kg. Having in mind the

economical situation in the rural environment, this is an important source for existence of a large, especially in years with large yields.

Beside the positive influence of climate conditions on forestry in the period 2001-2005, they also caused serious problems in its working activities. This regards primarily the effect of intensive precipitations in spring and summer months. The biggest activities in forestry (silvicultural measures, protection and harvesting) are undertaken during these months. Also, it has to be mentioned that forest roads in the Republic of Macedonia are mainly of poor quality, i.e. not tamponated or with asphalt. This has negative impact and effects on forestry in this period. Very often after intensive rainfalls, foresters weren't able to fulfill their duties, even days after the rains stopped. Besides that, because of the destructiveness of the heavy rains, some of the roads were ruined, and repairs were needed, adding expenses.

Because all of this, forestry has certain economic losses in its work, due to climate change. We can only approximate losses, because the P.E."Macedonian forests" has not performed analyses, especially not for the days when they weren't able to work because of the above mentioned conditions.

#### **4. Territories and areas most affected by climate change**

According to data from field's investigations, most affected areas by climate change in relation with health condition of forests, in the last 15 years, are areas that cover oak forests in the regions and phytocenoses defined by the experiences of the climatic classifications and adequate access for the territory of Republic of Macedonia and they are (Mapa 1):

1. Region with a sub-Mediterranean climate (50 - 500 m) (Gevgelija-Valandovo region) (SM);
2. Region with a moderate-continental-sub-Mediterranean climate (to 600 m) (MCSM);
3. Region with a hot continental climate (600 - 900 m) (HC);
4. Region with a cold continental climate (900 – 1 100 m) (CC);

The rest regions are:

5. Region with a sub-forest-continental-mountainous climate (1 100-1 300 m) (SFCM);
6. Region with a forest-continental mountainous climate (1 300 – 1 650 m) (FCM);
7. Region with a sub-alpine mountainous climate (1 650 – 2 250 m) (SAM);

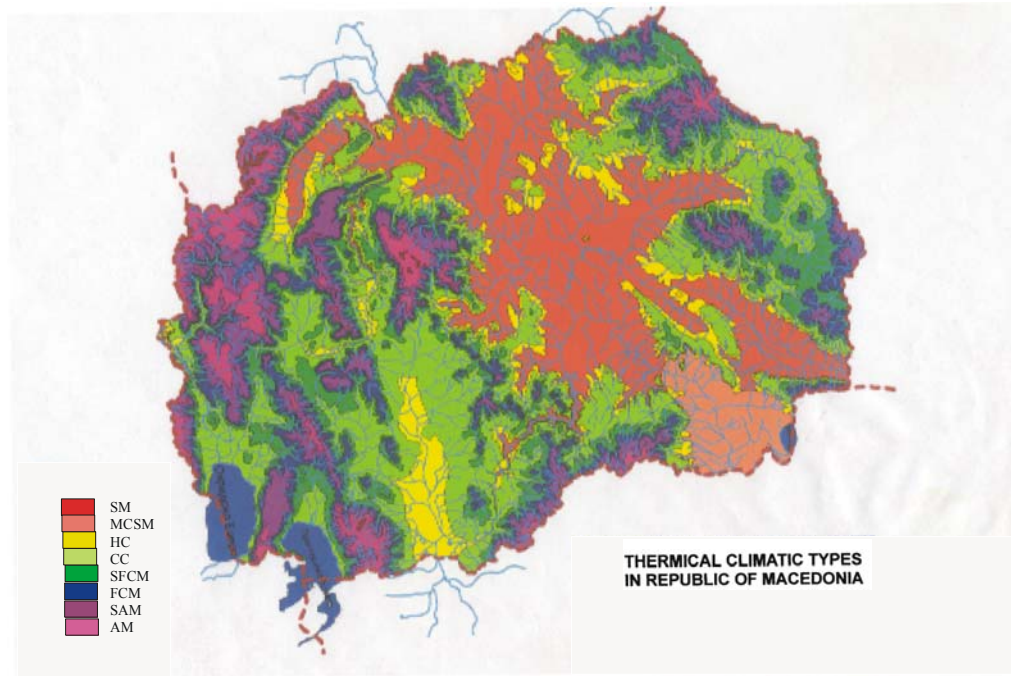
Also, according to the previews the most affected plant communities are:

1. ass *Coccifero-Carpinetum orientalis* **Oberd.emend.Ht** - Region with a sub-Mediterranean climate
2. ass *Quercu-Carpinetum orientalis macedonicum* **Rud.apud.Ht** - Region with a moderate-continental-sub-Mediterranean climate
3. ass *Quercetum fraineto-ceris macedonicum* **Oberd. Em end Ht** - Region with a hot continental climate
4. ass *Orno-Quercetum petraeae* **Em** - Region with a cold continental climate

These actually are all forest areas in Macedonia with altitude till 1 200 m above sea level. Here are detected the biggest negative changes caused by drought period (till year 2000) and biggest positive changes as result of wet period (from year 2001 till 2006). It can be noticed through data for crown transparency and dieback of parts of tree or whole trees, both at oak and fir (especially at oak), explained above.

The same conclusion can be said also and in relation of the influence of the climate change of forest fires. It is obvious the difference on burned area, number of forest fires and caused damages in the period till year 2001 (dry and hot period) and after year 2001 till today (wet period during whole year). Concerning to forest fires, this is seen through all territory of Macedonia.

Map 1



## **5. Assessment of the species migration-movement from their current location as a result of adaptation to climate change**

On the global level today exist knowledge's, but also assumptions, that because of increment of air temperature and decrement of precipitations migration of certain tree species are happening on highest altitudes and latitudes. In order to be in position to make conclusion that the same is happening in Republic of Macedonia we need some preconditions, for example:

1. We need data at least 20 years old monitoring of phytochenological composition of our forests but according to climatic changes point of view.
2. The occupation of new territories of some tree species in Macedonia, especially pasturelands, should to be taken into consideration also in context of drastically decreased number of livestock (especially sheep). More precisely, it should be taken into

consideration that a big part of high mountain pasturelands have been abandoned and forests are again covering previously deforested areas,.

3. Because of the large number of climatic types and subtypes on a small surface the number of tree species and plant associations is very big. So, in that richness and mixture of plant species (trees, bushes and grass) it is very difficult (for short period) to make proper conclusion for their movement into space and time.

However, in the last ten years occupation of new areas from some tree species has been registered. For example, *Pinus peuce* – Macedonian pine according to scientific books can be found at maximum elevation of 2 200 m a.s.l. On Pelister Mountain, ten years ago, it was found exactly up to 2 200 m a.s.l, while today it has been registered as high as 2 600 m a.s.l. In the same time it is also covering lower altitudes (in fact, historically lowest) where it has been removed in the past by people. The situation is very similar on almost all abandoned pastureland in Macedonia (for example Bistra) where presence of some pioneer plant species, such as juniper, which are predecessors of the forests tree species, such as beech is registered

Still, as mentioned before, it is very difficult to make conclusions whether that movement as a result of climate changes, although the influence on that process is obvious.

## **6. Adaptation measures**

Part of the measures for adaptation are based on previous knowledge's for the influence of climate change on forestry, and part of them are based on data from scenario for climate change in Macedonia for next 100 years ( Table 9 and 10). That influences of the climatic changes stronger and earlier will be recorded in the region of oak forests it can be seen on the Isothermal map of Macedonia (Map 2), Isohietic map of Macedonia (Map 3) and Map of physical geography of the Republic of Macedonia (Map 4).

According to this scenario, climate changes that are expected in the next 50 years (till year 2050), expressed by air temperature in the summer months, average annual temperature, sum of precipitations in the summer months and average annual sum of precipitations, and in relation with the same data in the period 1961-1990, are not so drastically. In average, on whole territory of Macedonia is expected raising of air temperature in the summer period by 2 to 3 °C, and of average annual temperatures approximately by 2 °C.

Table 9

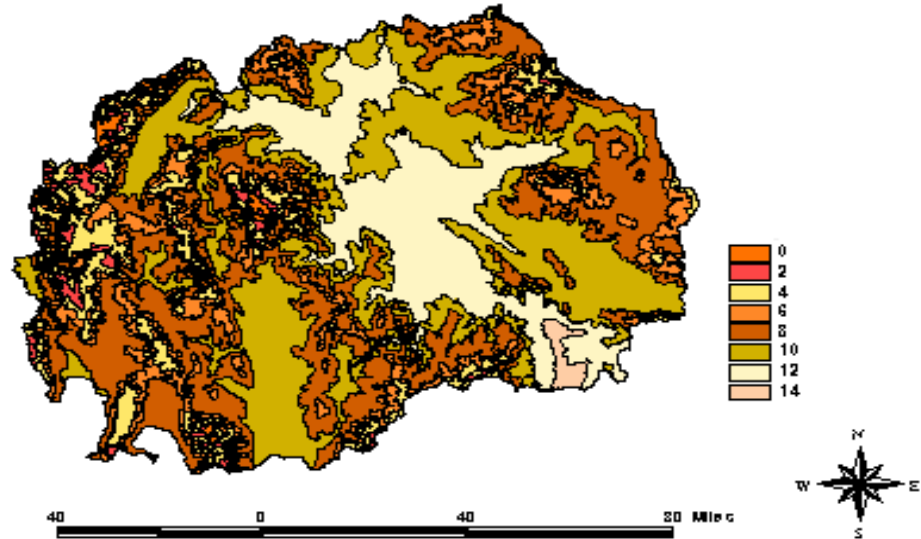
		AVERAGE TEMPERATURE [°C]									
Meteorological station	Prevailing climate impacts	JJA					ANNUAL				
		1961-90	2025	2050	2075	2100	1961-90	2025	2050	2075	2100
Gevgelija	Sub-Mediterranean	23,6	25,2	26,5	28,2	29,7	14,2	15,4	16,5	17,6	18,8
Nov Dojran	Sub-Mediterranean	23,6	25,2	26,5	28,2	29,7	14,1	15,4	16,5	17,6	18,8
Veles	Sub-Mediterranean	23,3	24,7	25,9	27,4	28,7	13,3	14,4	15,5	16,7	17,8
Strmica	Sub-Mediterranean	22,7	24,1	25,3	26,8	28,1	12,7	13,8	14,9	16,1	17,2
Skopje Petrovec	Sub-Mediterranean	22,2	23,6	24,8	26,3	27,6	12,1	13,2	14,3	15,5	16,6
Stip	Sub-Mediterranean	22,5	23,9	25,1	26,6	27,9	12,6	13,7	14,8	16,0	17,1
Bitola	Sub-Mediterranean/ Continental	20,8	22,2	23,4	24,8	26,2	11,0	12,2	13,4	14,7	16,0
Ohrid	Continental	19,8	20,9	21,9	23,1	24,2	11,1	12,1	13,1	14,1	15,1
Resen	Continental	18,0	19,1	20,1	21,3	22,4	9,5	10,5	11,5	12,5	13,5
Lazaropole	Mountain/Continental	15,0	16,4	17,5	19,0	20,3	6,8	8,1	9,3	10,6	11,9
Popova Sapka	Mountain	12,5	14,1	15,5	17,2	18,7	4,7	6,0	7,3	8,7	10,1

Table 10

		PRECIPITATION [%]									
Meteorological station	Prevailing climate impacts	JJA					ANNUAL				
		1961-90 mm	2025	2050	2075	2100	1961-90 mm	2025	2050	2075	2100
Gevgelija	Sub-Mediterranean	107,1	-4	-9	-14	-19	681,8	-3	-5	-9	-13
Nov Dojran	Sub-Mediterranean	118,4	-4	-9	-14	-19	625,4	-3	-5	-9	-13
Veles	Sub-Mediterranean	101,0	-6	-11	-18	-23	442,6	-3	-6	-9	-13
Strmica	Sub-Mediterranean	114,5	-6	-11	-18	-23	567,4	-3	-6	-9	-13
Skopje Petrovec	Sub-Mediterranean	107,6	-6	-11	-18	-23	504,4	-3	-6	-9	-13
Stip	Sub-Mediterranean	116,5	-6	-11	-18	-23	474,0	-3	-6	-9	-13
Bitola	Sub-Mediterranean/ Continental	111,8	-7	-14	-21	-26	599,8	-3	-6	-11	-15
Ohrid	Continental	96,4	-3	-9	-13	-18	698,3	-2	-3	-5	-8
Resen	Continental	88,4	-3	-9	-13	-18	707,9	-2	-3	-5	-8
Lazaropole	Mountain/Continental	155,6	-3	-7	-11	-16	1065,9	-1	-2	-3	-6
Popova Sapka	Mountain	197,5	-5	-10	-16	-22	991,7	-2	-4	-6	-10

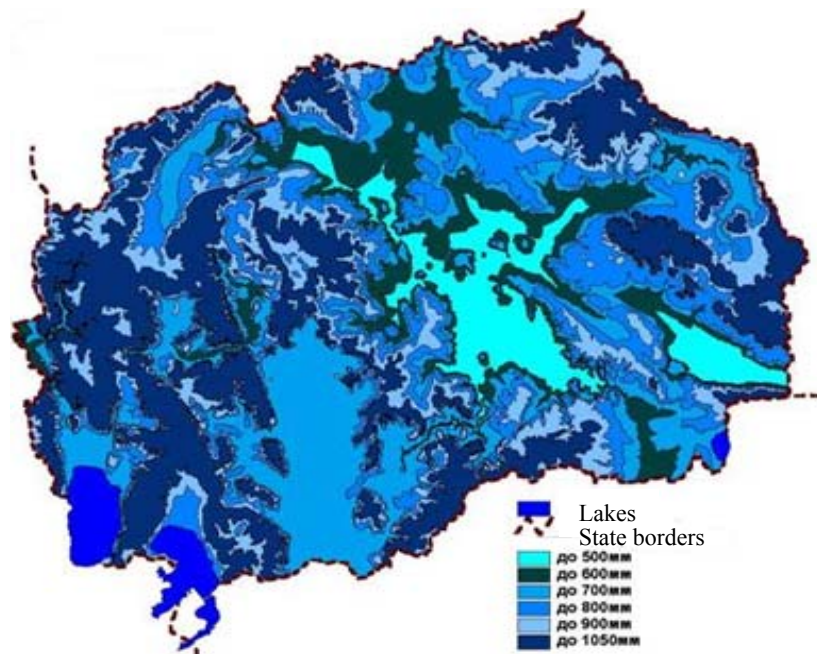
Isothermal map of the Republic of Macedonia (1951-1990) – °C

Map 2



Isohietic map of the Republic of Macedonia (1951-1990) - mm

Map 3



## Map of the physical geography of the Republic of Macedonia

Map 4



Changes are expected also for precipitations, i.e. till 2050 is expected decreasing of precipitations during summer months approximately for 10 % in comparison with the average sum in the period 1961-1990. Also, it is expected decreasing of the sum of average annual precipitations between -2 and -6 %. Biggest decreasing from 6% is expected in sub-Mediterranean and moderate-continental climatic regions of Macedonia.

According to experiences, also and from results of this scenario, till year 2050 are possible the following consequences from climate changes:

1. Because of increased air temperature and decreased precipitations, it is possible more intensive process of forest dieback, particularly in the oak's belt (till 1 200 m a.s.l.).

2. Also it is expected migration of tree species toward higher sea altitudes and change of floristic composition of current forests.
3. Because of physiological stress of trees, it is expected increased population of some pests (particularly insects and fungi).
4. Because of increased percentage of dead trees it will be increased amount of fuel material and because of that (increased air temperature and decreased sum of precipitations) are expected biggest number of forest fires and burned area.
5. All this, because of needs of taking appropriate measures during the forestry activities, will increase expenses in the forestry and it is expected to cause significant economical damages.

Measures that will have to be undertaken to adapt forestry in these condition are:

1. Forest management should be adapted in agreement with climate change by detailed measures predicted with Forest Management Plans. For example: The silvicultural measures should be in agreement with climate changes; The planning measures should be in agreement with climate changes; The selection of tree species for afforestation should be in agreement with climate changes e.t.c
2. To establish monitoring with purpose for following of the climate changes and their influence of the forest and forestry. Particularly regarding to health condition of forests, population of pests and phytocenological composition of the forests.
3. To undertake all preventive, preservative and direct measures for forest fire protection.
4. To establish measures, how the state to finance these kind of measures in the forestry, because some of them will not have economic justification.
5. Improvement of species composition of forests (natural and afforested) with endemic tree species, resistant to climate changes.

The preparatory of the Strategy for sustainable development of forestry in the Republic of Macedonia (adopted by Government of R. Macedonia in June 2006), were aware of the importance of climate changes on forest and forestry and they gave it appropriate place in the Strategy.

The previous measures will be presented with appropriate actions in the Action Plan (part of this Report). The actions that are predicted in the Action plan of the Strategy for sustainable development of forestry in the Republic of Macedonia will be included also in this Action Plan.

Because the period from 2 50 to 2100 is far away and we don't know if scenario fully will become real, in the following years, with the predicted measures and actions it has to be followed the situation and step by step to predict measures for that period, in accordance with reality and the scenario.

## **7. Establishment of climate-related database**

One of the most important preconditions for keeping up and understanding climate changes and its influence on forests and forestry is the existence of quality databases. In this moment there is no such database in Macedonia.

With reconstruction of ICP Forests network (Level I) this year in Macedonia there are preconditions for monitoring of health conditions of our forests. But, with that only part of our needs are satisfied.

The next step is to establish sample plots in certain forests types (most vulnerable and economically important) where will be measured all meteorological elements regarding climate changes. The existing network of meteorological stations in the Republic of Macedonia is not proper regarding to climate changes and their influence on forests and forestry.

Also, in the forest management plans there should be an addition for the notification of all climatic extremes which have influence of forests and work in forestry in general.

That database should be situated in the Ministry of agriculture, forestry and water supply and for its establishment the Ministry of agriculture, forestry and water supply – Skopje, and Faculty of Forestry-Skopje, P.E. "Macedonian forests"-Skopje, the Republic Hydrometeorological Institute - Skopje, Ministry of environment and spatial planning-Skopje and all relevant institutions should be involved.

## **8. Resistant species of climate changes**

Because one of the measures is afforestation of bare lands and areas after cutting of the forest, mostly with endemic tree species, it will be needed to know the species appropriate for that. Also, because the largest part of areas for afforestation exist in areas of the oak forests, it is normal these species to be from oak gender. As most resistant to climate changes (drought resistant mainly), in our state, are the following endemic species of oak:

1. *Quercus pubescens* – Downy Oak
2. *Quercus macedonika* – Macedonian Oak
3. *Quercus coccifera* – Kermes Oak (In our condition as a bush and appropriate for the region of Gevgelija and Valandovo. Without economical significance, fire susceptible and although is draught resistant it is not recommended for afforestation.)

Besides these species, in the same region, as endemic species resistant of climate changes (draught and high air temperature resistant mainly) can be found:

1. *Carpinus orientalis* – Oriental hornbeam
2. *Fraxinus ornus* – Manna Ash
3. *Pistacia terebinth* – Turpentine tree

These six previous species can be used to create monocultures (forests with one tree species), but also and for mixed forest by constitution (what is better solution).

Beside broadleaved species, for afforestation, can be used the following endemic coniferous species:

1. *Pinus nigra* - Austrian pine (from 700 to 1700 m a.s.l.)
2. *Juniperus excelsa* - Greek juniper ( up to 1 000 m a.s.l.)

This two species has shown as resistant of climate changes, especially of draught and high air temperature.

## **9. Models application**

In this moment several models for climate behavior and effects of climate change exist. But all of them are of global level. This means that it is almost impossible to use them and to get data with high accuracy for small areas such as Macedonia. So, we should put efforts to adapt already existing models or create our local one.

In order to achieve aims of this project at appropriate levels of quality and accuracy, the following sources were utilized (books, projects, analyses etc):

1. **Macedonian's forest national communication under the United Nations framework convention on climate change**  
Skopje 2003
2. **The characteristics of the climate-vegetation-soil zones (regions) in the Republic of Macedonia**  
Skopje, 1996
3. **Climate change scenarios for Macedonia**  
Preliminary report Review of methodology and first results  
Oc. Dr. Klemen Bergant  
Noa Gorica, Slovenia, 2006
4. **Fluctuations and oscillations of air temperatures and precipitations in the Republic of Macedonia**  
Scientific project, Skopje 2002
5. **Annual report for 2004 year**  
P.E. "Macedonian forests", Skopje 2005
6. **6. Monitoring and researching of the influence on polluted atmosphere and deposition on the forests vegetation**  
Final report, Skopje 2005
7. **Strategy for sustainable development of Forestry in the Republic of Macedonia**  
Skopje, 2006
8. **Agricultural and forest Meteorology**  
Volume 103,NOS.1-2, Oxford 2000
9. **UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE – ICP Forests**  
**Manual Part II Visual Assessment of Crown Condition, 2004**
10. **Influence of some climatic elements and air pollution on the forest dieback process in the Republic of Macedonia**  
Ph.D, Skopje 1998

- 11. Data from Republic Hydrometeorological Institute - Skopje**
- 12. Data from Ministry of Internal Affairs (MIA) - Skopje**
- 13. Data from Ministry of Agriculture, Forestry and Water Supply (MAFWS) - Skopje**
- 14. Data from P.E. "Macedonian forests" - Skopje**