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National University of Life and Environmental Sciences of Ukraine (NULESU)

REPORT

ASSESSMENT OF DISTURBANSES IN UKRAINIAN FORESTS

Project: “GESAPU—Geoinformation technologies, spatio-temporal approaches, and full carbon account for improving accuracy of GHG inventories”,

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Abstract

General overview of disturbances of Ukrainian forests due to impact of natural and anthropogenic factors presented in the report. Analysis based on national statistics and statistics of largest permanent user of forests in Ukraine - State Agency of Forest Resources. During last decade all sources reported increasing of forested lands on national level, but in some oblasts (Chernivetska, Ivano-Frankivska and some others) amount of forested lands decreased. In total annually 60-70 thousands ha of forests of Ukraine (0.7% from total forested area) disturbed essentially with total loss of aboveground carbon in biomass and partial loss of soil carbon and up to 1.6 million ha (17.4%) disturbed partially. More precise assessment of illegal logging could change this assessment essentially.

Introduction

Disturbances of forests usually depend of interactions and impact of complex of anthropogenic, biotic and abiotic factors. Among social-economic factors usually next factors are essential: land use, forest policy, peculiarities of forest management, illegal logging, general level of economy and markets, labour force etc. All abovementioned has been changing drastically during last decade and impacted forests and forest management. Privatisation of agricultural (former kolhoses) lands in 2001 was implemented without taking into account of ownership on forest protection belts that stimulated deterioration of them in many regions of Ukraine. Large areas of agriculture lands that new owners were not able to cultivate due to lack of credits and support stimulated increasing of fires that very often moved from degrade agriculture lands to forests. Decreasing of income of rural population and unemployment stimulated increasing of illegal logging. General trends of reducing of rates of economy growth push forestry enterprises to use all available ways to get immediately profit from forests that very often negatively impacted forest health and consequences in increasing of forest insects diseases and forest dieback. Regional peculiarities of natural and social – economic conditions for forest management vary very much from heavy forested Carpathian Mountains with high level of illegal logging, unemployment and lack forest roads to Steppe zone with low percentage of forest lands and low forest productivity. Temporal and regional dynamic of forest disturbances need to be taken into account during assessment of carbon deposition and fluxes in forests of Ukraine.

1. Dynamic of area of forested lands in Ukraine

Area of forest lands of Ukraine during post-soviet period constantly has been changing. Nature of those changes related with developing of a new principals of forest management, property and land use changes. Another problem of forested lands accounting is different approach of different agencies in understanding this term and different reporting periods.

Accordingly to State Agency of Land Resources of Ukraine by 1 January 2013 total area of lands covered by forest in Ukraine reached 9683,3 thousands ha **(**http://land.gov.ua/zvitnist/statystyka/104693-zemelnyi-fond-ukrainy-stanom-na-1-sichnia-2013-roku-ta-dynamika-ioho-zmin-v-porivnianni-z-danymy-na-1-sichnia-2012-rokiv.html**),** while in 2006 - 9400,2 million ha were reported (Cadastre, 2012). So, increasing 283,1 thousands ha were reported during last 7 years. This is related to all forests that are in use of more than 50 different agencies. The reason of this growth is only partially related with planting of new forests, while most part of those new forest covered lands showed up in the statistics due to including forest windbreak shelterbelts in forested lands category that managed by forest enterprises under Ministry of Agricultural Policy and Food of Ukraine (MAPFU) - that were not accounted earlier as forestry lands but as agriculture lands.

Most important constant user of forest lands in Ukraine is the State Agency of Forest Resources of Ukraine (SAFRU) that manage at the moment 66% of all forest lands of (http://dklg.kmu.gov.ua/forest/control/uk/publish/article?art_id=62921&cat_id=32867).

SAFRU has best among other agencies system of accounting of forest land's changes and so could be useful for understand of forest land dynamic in different oblasts of Ukraine. Closer look on regional aspects and temporal dynamics of forested lands of SAFRU demonstrates that during 2002 – 2011 total area of forested lands of SAFRU increased only 0.4 thousands ha (Table 1, Annex 1).

Table 1. Regional aspects and temporal dynamics of area of forested lands of SAFRU and forested lands reported in the National report of carbon deposition in forests

Oblast	Total area of forested lands of SAFRU by oblasts, thousands ha (Cadastre, 2012)			Area of forested lands used for calculations of changes of carbon deposition in Ukraine, thousands ha (National Cadastre, 2011)
	2002	2011	Difference 2002-2011	Difference 2009-2000
Ukraine	6293,1	6293,5	0,4	-36,6
Crimea	200,9	200,7	-0,2	-2,4
Vinnitska	201,2	199,9	-1,3	-5,7
Volynska	441,9	438,6	-3,3	-2,7
Dnipropetrovska	64,9	65,7	0,8	-11,6
Donetska	97,2	92,5	-4,7	-4,3
Zhytomyrska	662,1	660,6	-1,5	25,6
Zakarpatska	449,9	460,8	10,9	-0,9
Zaporizka	22,4	34	11,6	11,5
Ivano-Frankivska	437,4	426,5	-10,9	-2,8
Kyivska	340,2	355,1	14,9	-1,7
Kirovogradska	101,1	103,4	2,3	-3
Luhanska	230,6	228,2	-2,4	-20,2
Lvivska	431,3	428,1	-3,2	7
Mikolaïvska	35,3	37,3	2	-5,3
Odesska	86,9	90,2	3,3	-9
Poltavska	152,4	157,3	4,9	8
Rivnenska	582,9	588,5	5,6	-2,6
Sumska	256,4	255,7	-0,7	-2,7
Ternopilska	142,9	143,9	1	-2,5
Kharkivska	284,3	282,3	-2	6,1
Khersonska	84,9	77,3	-7,6	-8,4
Khmelnytska	168,4	166,2	-2,2	-1,3
Cherkaska	260,1	255,5	-4,6	-6,6
Chernivetska	173,5	160,4	-13,1	-0,1
Chernigivska	354,7	355,8	1,1	-0,8

In number of important forestry regions forested lands decreased essentially during reported period in particularly: Chernivetska oblast (-13.1 thousands ha), Ivano-Frankiska oblast (-10.9), Khersonska (-7,6), Cherkasska, Donetska (- 4.6 and -4.7 accordingly), Volynska, Lvivska, Khmelnitska oblsasts (-2.2 -3.3) (Fig. 1, 2).

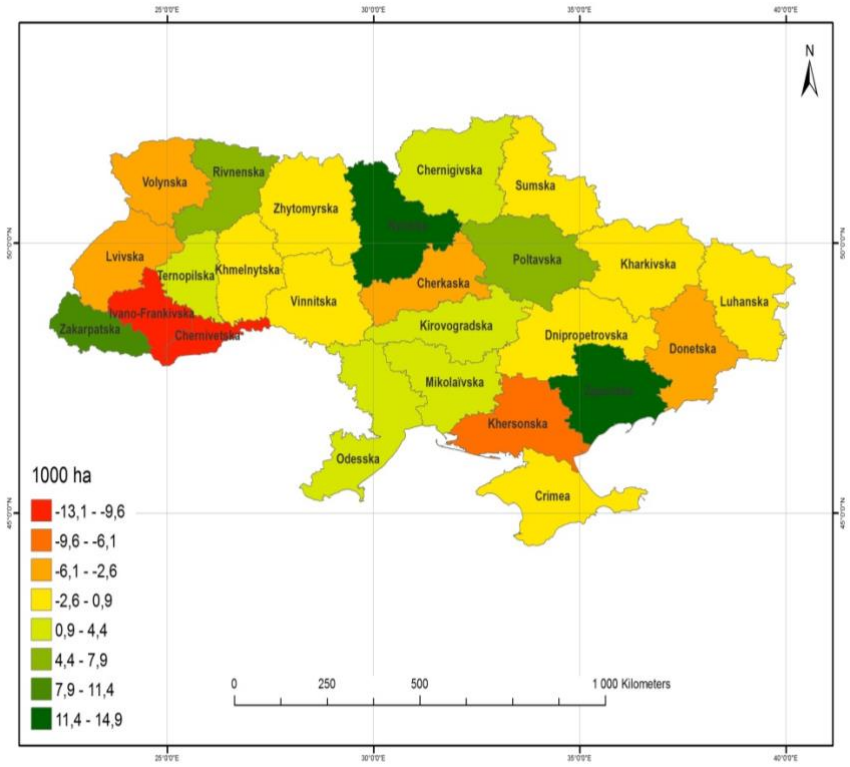


Fig.1 - Difference of area of forested lands of SAFRU by oblasts for period 2002-2011, thousands ha (Source: Cadastre of forest lands, 2012)

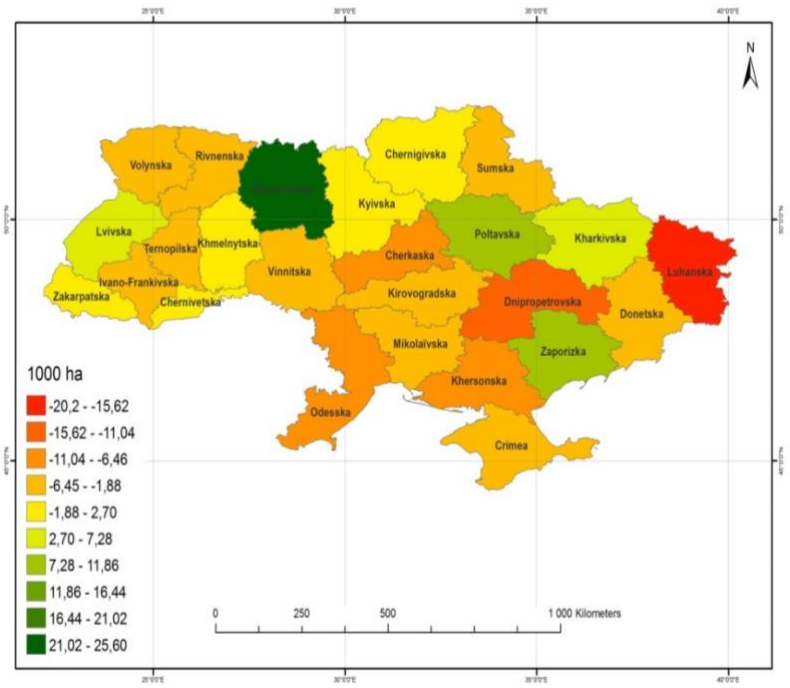


Fig. 2 - Difference of area of forested lands used for calculations of changes of carbon deposition in Ukraine during 2000-2009, thousands ha (Source: National cadastre of greenhouse gases, 2011)

In the same time increasing of forested lands took place in Kyivska oblasts (+14.9 thousands ha), Zaporizska, Zakarpatska oblasts (+11.6 and +10.9). Those changes mostly reflect two main tendencies of changes of SAFRU's area forested lands: privatization of part of lands of SAFRU and transfer of lands from other Agencies (Agriculture, Military) to SAFRU. Loss of 7.6 thousands ha in Kherson related to large forest fire occurred in August 2007.

Quite different picture of regional dynamic of areas of forested lands (all agencies) shows data of the "National Cadastre of anthropogenic emissions from the sources and removal by deposition by sinks of greenhouse gases in Ukraine", (2011) shown on last column of Table 1 and Figure 2. Accordingly to this source during 2000-2009 decreasing of 36.6 thousands ha of forested lands of Ukraine reported. Largest decreasing reported in Luganska oblast – 20.2 thousands ha, in Odessa, Cherkassy, Kherson and Dnipropetrovsk - decreasing varied from 6,6 to 11.6 thousands ha. Most of those oblasts located in the Steppe and Forest–Steppe zones with low percentage of forest cover. Largest increasing of forested lands reported in Ghytomyrska oblast (+25.6 thousands ha), Zaporizska (+11.5), Lviivska, Poltavska, Kharkivska (+ 6.1-8.0). In all abovementioned oblasts reasons of changing of area of forested lands require special analysis..

Summarizing short analysis of forested lands changes in Ukraine during last decade need to be mentioned that official forest land statistics system need to be improved and harmonized among different agencies and for national level as a whole. It is also need to develop more precise statistical definition of term "forested lands". For example more clearly should be described what kind of forest windbreak protected belts (for example by parameter of width of belt or amount of rows in the belt) could be included in "forested lands" category. Meanwhile special study based on remote sensing data needed to be done on statistically selected areas of typical forest regions of Ukraine to compare satellite data with official statics. Based on presented results could be concluded that accordingly to main official sources area of forested lands of Ukraine have positive dynamic since 2000. Decreasing of forested lands shows in the national greenhouse gases cadaster is not significant on national level - 3,78E-04% and so reducing of forested lands could not be counted as important disturbance factor of forests of Ukraine.

2. Harvesting of forests

Harvesting of forests dependents from level of age structure of forests and their distribution by exploitation and protection purposes, socio-economic development of country, rural development, level of income of population and many other factors such as forest policy, forest management etc. Intensity of harvesting - one of the main criteria of sustainability of forest management system and together with area gives information about how economically efficient and sustainable forest management are. In the same

time harvesting, especially final one - usually is main disturbance forest factor. In 90-s Ukraine entered into the difficult transition period: from planned socialist economy to open market economy and now - 25 years after 1991 - still many steps on this way ahead. Below analysis of dynamic of different kind of harvesting as well its regional peculiarities is presented.

2.1. Total volume of harvested timber, share of final and other harvesting

In Ukraine level of total harvesting was relatively stable during last decade of XX century and varied from 11.2 to 14.1 million cub m annually. For the same period annual volume of timber obtained from final harvesting was on level 4.3-5.7 millions of cub m, while during other harvesting (all kind of thinning, sanitary and others) was obtained 6.4 – 9.4 millions of cub m annually (Fig. 3, Annexes 2, 3).

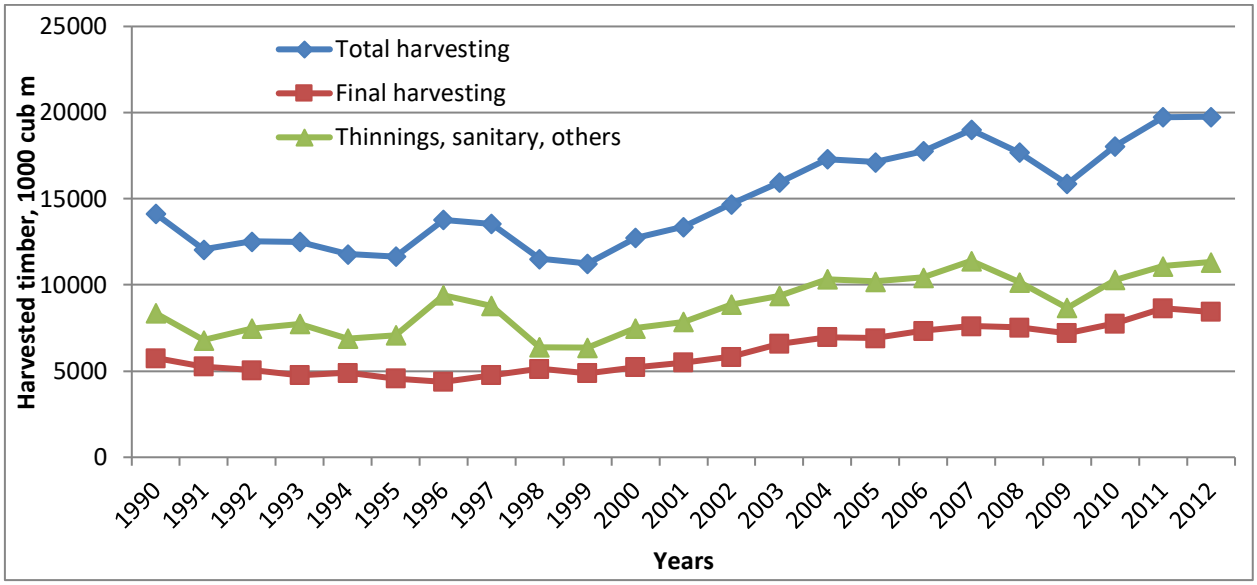
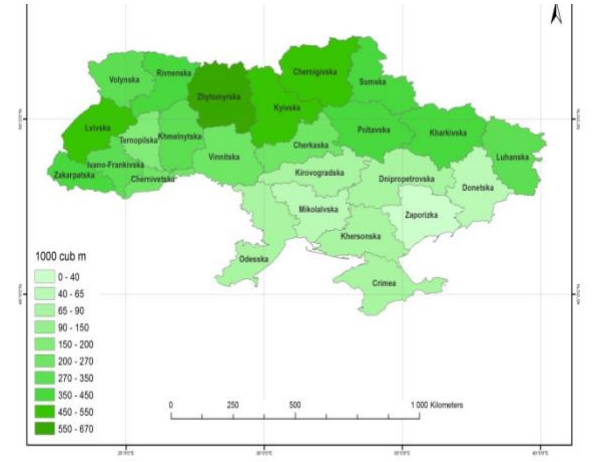


Fig. 3 - Harvesting of timber in Ukraine (final harvesting, thinning, sanitary) total stock, 1000 cub m (Source: Statistical yearbook of Ukraine, 2012)

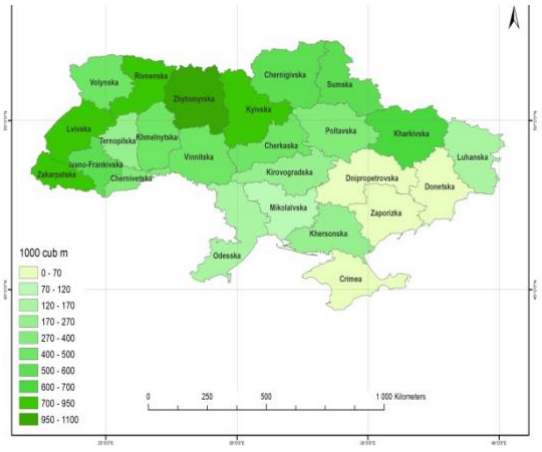
During 90-s important changes on level of forestry enterprise took place - in new market economic conditions they have to look for consumers themselves. So during 90-s forestry enterprises started to increase export of timber and accumulate costs for development of primary processing of timber to reach more markets. Starting since 2000 – 2001 most enterprises in heavily forested areas (Polessie and Carpathians M-s) – were able to sell both round wood timber and processed assortments both for internal and abroad markets. This together with ageing forests allowed to increase of total harvesting in 1.7 – 1.9 times to level 19,0 million cub m per year (2007), including 7.6 cum m of final harvesting and 11.4 million cub m of other kinds of cuts. World financial crisis of 2008 impacted harvesting reducing total volume of harvested timber to 15.8-17.6 million cub m for 3-4 years, but in 2011 growing of volume of harvested timber continued.

It is important to make separate analysis of dynamic of final and other kind of harvesting by regions as their impact on forest environment and carbon pools very much differ in Ukraine. Final harvesting in Ukraine usually are clear-cuts (94-96%) related with radical disturbance of environment and followed by partial loss of carbon of soils (via plowing),

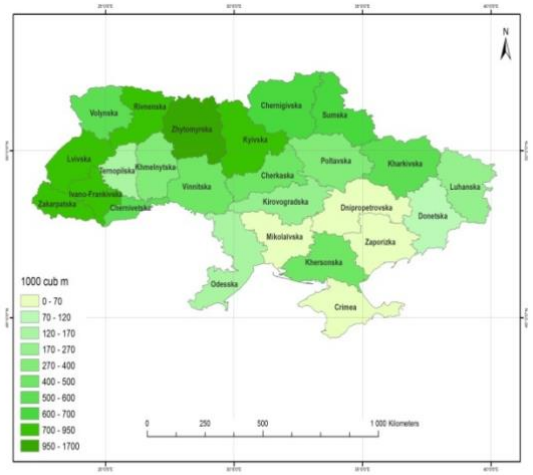
forest litter (skidding), branches of trees (burning or piling) most of timber biomass (removal from site roundwood).Same type of impact related with clear sanitary cuttings and so called forests renewable cuts. All those types of cuts has been steadily growing during last decade. During others types of cuts - four kinds of thinning and selective sanitary mostly consequences by remove from stands 10-20% of timber growing stock and burning of branches from that trees and so not significantly reduce pool of carbon. Intensity of timber removal during thinning by oblasts are very much differ in different years (Fig. 4, Table 2).



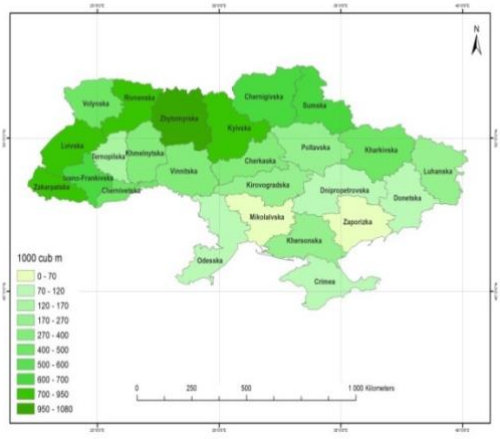
2000



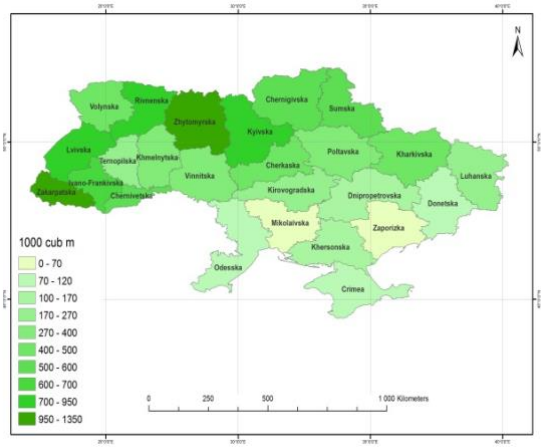
2005



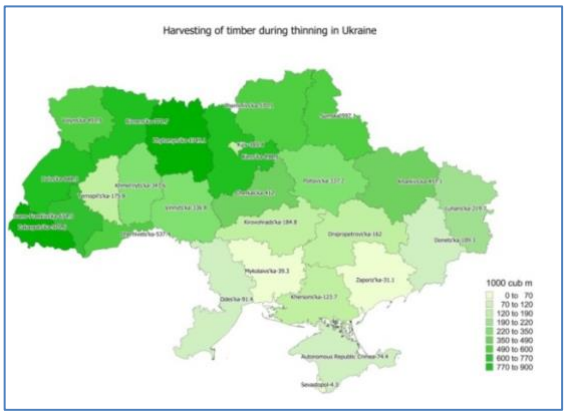
2007



2008



2011



2012

Fig. 4 - Harvesting of timber during thinning, sanitary and other cuttings per regions of Ukraine during 2000–2012, 1000 m3

Table 2 - Harvesting of timber during thinning, sanitary and other cuttings by oblasts of Ukraine, 1000 m3

Oblast, region	Years						
	2000	2005	2007	2008	2009	2010	2011
Ukraine	7017,4	10205,9	11076,6	10054,8	8600,3	10223,2	10984,9
Crimea	65,7	69,1	69,0	81,1	75,5	67,6	74,4
Vinnitska	259,2	417,1	403,1	367,9	327,1	350,9	336,8
Volynska	347,8	400,9	509,9	484,5	418,9	540,7	491,9
Dnipropetrovska	75,7	57,0	55,4	74,3	43,4	51,0	162,0
Donetska	42,6	59,4	71,6	71,6	75,4	93,5	109,3
Zhytomyrska	651,3	1087,6	1060,6	1078,7	1021,9	1199,8	1349,1
Zakarpatska	434,4	759,1	872,7	756,1	738,1	871,2	975,6
Zaporizka	23,6	20,2	23,3	26,0	28,1	32,8	31,1
Ivano-Frankivska	322,7	578,1	790,6	654,0	637,1	748,3	654,3
Kyivska	526,0	834,7	778,2	739,9	511,5	775,0	898,5
Kirovogradska	78,3	195,1	188,4	178,2	150,2	156,2	184,8
Luhanska	272,2	147,8	180,0	182,2	173,7	248,1	219,7
Lvivska	478,5	706,9	873,5	756,5	547,0	681,2	848,3
Mikolaïvska	41,0	76,1	53,9	41,4	39,5	38,9	39,3
Odesska	74,5	151,8	130,0	106,2	97,3	88,4	91,4
Poltavska	395,4	291,3	284,8	267,7	281,8	329,5	337,2
Rivnenska	432,8	784,2	786,1	772,0	713,5	854,4	770,7
Sumska	407,1	559,1	667,9	633,3	451,0	531,0	597,1
Ternopilska	187,7	178,4	158,6	135,1	135,4	142,1	175,8
Kharkivska	423,7	638,6	547,1	461,4	436,7	424,4	457,1
Khersonska	87,1	173,3	485,0	208,3	166,3	164,5	123,7
Khmelnytska	310,2	459,7	388,2	336,9	311,7	326,4	347,6
Cherkaska	269,0	421,5	404,2	388,5	344,4	402,4	412
Chernivetska	207,6	397,1	501,3	441,8	394,9	475,2	537,4
Chernigivska	485,2	584,7	664,5	650,1	373,2	444,6	570,1

As it is shown in the map largest timber stock taken as a result of other than final harvesting in Ghytomyr and Transcarpathian oblasts - where 770 and more thousands cub m were removed in 2012. Four oblasts harvest during thinning less - from 600 to 770 cub m - e.g. Lvivska, Ivano-Frankivska, Rivnenska, Kyivska. In other oblasts removal of timber with thinning 2-3 times lower – because of lower productivity and general low percentage of forest lands. Area of final logging since 2000 increased from 22,2 thousand ha to 30.8 thousand ha in 2012.

In terms of temporal dynamic during the period 2000 – 2011 while average in Ukraine increase of timber removal during other than final cuts was 1.56 in some regions this amount increased more than 2.5 times – first of all in Chernivetska, Donetska (2.6) and Kirogovradska (2.3) oblasts. It should be noted that Donetska and Kirovogradska oblasts considered as low forested and reasons for so intensive intermediate harvesting need to be analysed additionally. In general volume of timber removal during thinning and sanitary cuts very much dependents on age structure of forests in oblasts, regularity of previous

silviculture measures and forest health. It is known that in Ukraine mass dieback of some species like oak, spruce, pine and birch occur last decade.

Essential negative changes in structure of different kind of harvesting took place in Ukraine during first decade XXI century (Popkov, 2013). Volume of timber harvested by sanitary and so called “forest renewable cuttings” has been growing from 25% in 1990 to 44% in 2008, while all thinning’s reduced from 33% to 8% for the same period (Fig. 5).

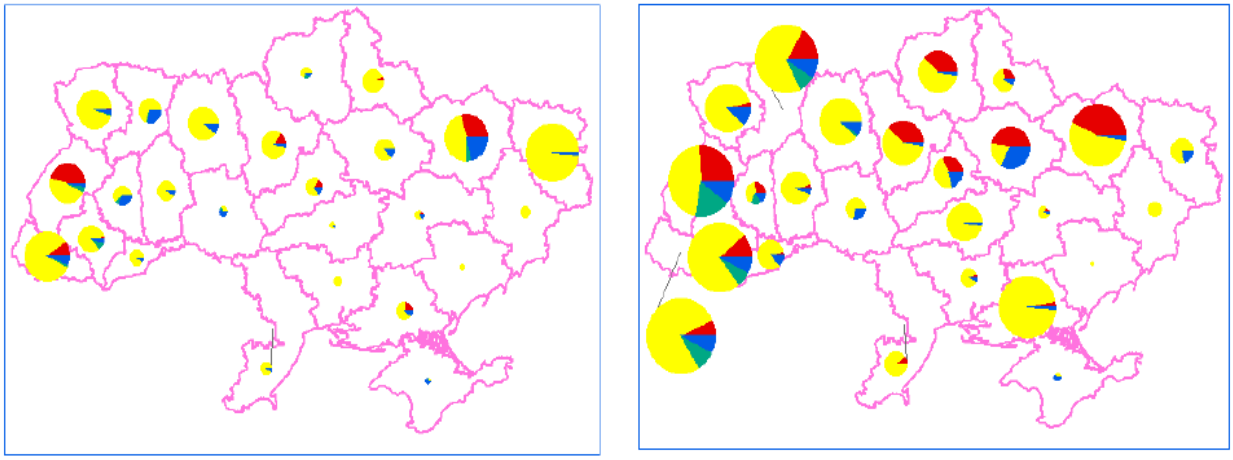


Fig. 5 – Changes of volume and structure of “other than final” cuts during period 1998 (1.654 million cub m) – 2007 (3.755 million cub m) (Popkov, 2013)

Yellow – clear sanitary cuts; Red – forest renewable cuts;
Green – reconstruction cuts; Blue – other cuts related and not related with forestry

To avoid stump payment tax and to increase economic feasibility of forest management most forestry enterprises dramatically increased share of thinning and sanitary cutting in middle-aged and premature forests that allowed them to get much better quality of harvested assortments and diameter without tax payment. Increasing of “other” cuttings happened with same main commercial tree species as were cut earlier by thinning. Due to this reason species composition of Ukrainian forests essentially changed by reducing of share of valuable commercial species (oak, pine, beech, fir, spruce) and increasing of so called secondary species (aspen, hornbeam, birch, alder etc.) with low commercial value. This tendency is reducing growing stock and commercial value of forests in the age of final harvesting on 30-40% in compare with etalon stands. But at the moment it is difficult to assess how carbon sink was be affected and special studies are needed.

2.2. Illegal logging

Illegal logging is one the major problems that need to be coped on the way of transition of Ukrainian forestry to principals of SFM. A number of publications and reports devoted to this problem were published in Ukraine during last decade (Kuemmerle, 2009, FERN, 2009, Pavelko, Skrylnikov, 2010, Risks, 2009). Last year ENPI FLEG II project (http://www.fleg.org.ua) made important contribution in understanding of roots and definitions and types of activity that can be defined as illegal logging. WWF sponsored a

number of important projects related with forest certification in Ukraine and part of it is devoted to illegal logging issue (http://sfmu.org.ua/ua/illegallogging). Research publications, numerous media and NGO's reports prove that Illegal logging is a significant disturbance factor for Ukrainian forests.

There are next main types of illegal logging need to be considered during disturbance analysis in Ukraine (Pavelko, Skrylnikov, 2010):

- logging without needed permission;
- false declaration of volume and value of harvested timber;
- logging outside the delineated cutting area;
- obtaining permits for logging with use of corruption schemes;
- arbitrary sanitary cuttings;
- illegal taken of forest land for construction or mining and further harvesting trees.

All kinds of illegal logging recognized by national legislation and international definitions occur in Ukraine. In the same time no any Governmental agency in Ukraine does not collect, analyse and publish generalized data on the volumes of illegal logging, assessment of illegal export of timber or undervaluation of wood price from all available sources. Official information can be obtained from next main sources: State Agency of Forest Resources of Ukraine (SAFRU), media publication, reports of Ministry of Interior and the State Environmental Inspectorate and its territorial bodies. Unofficial assessments of experts of illegal logging scale vary from 1 to 10% of total volume of harvested timber.

For official statistics purposes SAFRU uses the term "unauthorized felling". Officially published dynamic of unauthorized felling in Ukraine per oblasts during 2007-2012 presented in Table 3. First of all needed to be mentioned that mistakenly 961.7 thousands cub m were stated as illegal logging in Kherson oblast in 2007. This timber were harvested with official permissions during salvation logging by forestry enterprises and population after large wildfire in August 2007 when up to 9000 thousands ha of pine forests of Oleshkivski sands arena were burned. As a result in 2007 mistakenly in all Ukraine 1.0 million of cub m of illegal harvesting was reported which is not true.

In general, accordingly to official statistics during 2007–2012 annual volume of timber harvested illegally were between 24.4 (2012) and 36.9 thousands cub m (2008) excluding Kherson fire case. In terms of share of total volume of harvested timber in Ukraine from all kind of cuts this means very low level - 0.12-0.19%. For the reporting period amount of illegally logged timber in most regions slightly decreased (0.1-2.0 thousands cub m) or did not changed at all. Largest reported volumes of illegally logged timber occur in most significant forestry regions of the country - Lvivska (5,1-8,8 thousands cub m), Transcarpathian (2,6-8,3) and Ivano-Frankivska (0.9-5.9) oblasts. In Polesskiy region reported illegal logging 5-10 times less than in abovementioned oblasts.

Table 3 - Illegal logging in Ukraine by regions during 2007–2012, 1000 cub m3

Region / Oblast	2007	2008	2009	2010	2011	2012
Ukraine	1000,232	36,925	28,584	25,461	34,466	24,435
Crimea	0,384	0,321	0,448	0,427	0,245	0,202
Vinnitska	0,653	0,482	0,528	0,361	0,546	0,131
Volynska	1,548	1,08	0,637	0,556	0,627	1,338
Dnipropetrovska	0,084	0,719	0,135	0,322	0,218	0,205
Donetska	0,62	0,645	0,642	0,399	1,322	0,771
Zhytomyrska	1,174	1,145	2,84	1,2	1,133	0,855
Zakarpatska	4,728	8,284	5,477	2,599	5,793	3,099
Zaporizka	0,05	0,054	0,216	0,02	0,295	0,214
Ivano-Frankivska	5,965	3,623	1,506	0,92	1,702	1,512
Kyivska	0,756	2,173	1,722	1,574	1,26	0,751
Kirovogradska	0,263	0,099	0,674	0,078	0,285	0,212
Luhanska	0,795	0,746	0,454	3,43	0,896	0,594
Lvivska	5,101	7,41	5,178	7,68	8,803	7,874
Mikolaïvska	8,338	0,017	0,116	0,261	0,287	0,016
Odesska	0,108	0,484	0,153	0,17	3,67	0,996
Poltavska	0,363	0,297	0,411	0,357	0,214	0,109
Rivnenska	2,539	1,914	0,914	0,846	1,375	1,052
Sumska	1,002	0,574	0,378	0,338	1,546	0,439
Ternopilska	0,426	0,74	0,262	1,272	0,277	1,645
Kharkivska	0,238	1,428	1,761	0,687	0,922	0,828
Khersonska	961,716	0,105	0,177	0,039	0,251	0,208
Khmelnytska	0,223	0,255	0,958	0,321	0,383	0,074
Cherkaska	0,354	0,578	0,743	0,38	0,16	0,148
Chernivetska	1,737	2,033	1,198	0,602	0,897	0,451
Chernigivska	0,963	1,267	0,844	0,474	0,99	0,338
Kyiv city urban forests	0,028	0,389	0,212	0,024	0,289	0,178

In conclusion need to be underlined that official figures of illegal logging far from real and special institutional and other efforts need to be done to make more precise assessment. One of the most important problem here that illegal logging in many cases supported by local population in Carpathian region and by personal of forestry enterprises - so not only new control measures need to be implemented but new local and national policy in wider understanding of this term, including efforts in improvement of employment possibilities for local population and others. Also statistics need to be taken from Ministry of Interior on cases of illegal logging that usually unavailable and is not included at the official figures.

3. Area of forests damaged due to impact of insects and diseases

Insects and diseases are major disturbance factor of Ukrainian forests along with harvesting and fires. Concert action of numerous factors including climate and land use changes, anthropogenic impact change forest environment and forest ecosystems experienced heavy attacks of insects and diseases that indicate early stages of processes of disappearing of those kinds of forests in near future. A number of review done with analysis of reasons and dynamic of impact of insects and diseases on national level and for some regions (Usckiy, 2011, Complex, 2010, Buksha, 2011).

Statistics show that area of forests of Ukraine with signs of damage from insects and diseases grew more than 2 times for the period 1990 – 2004 and reach its historic maximum - 753.2 thousands ha. Same level almost was reached in 2011 and 2012 (Fig. 6, Annex 4).

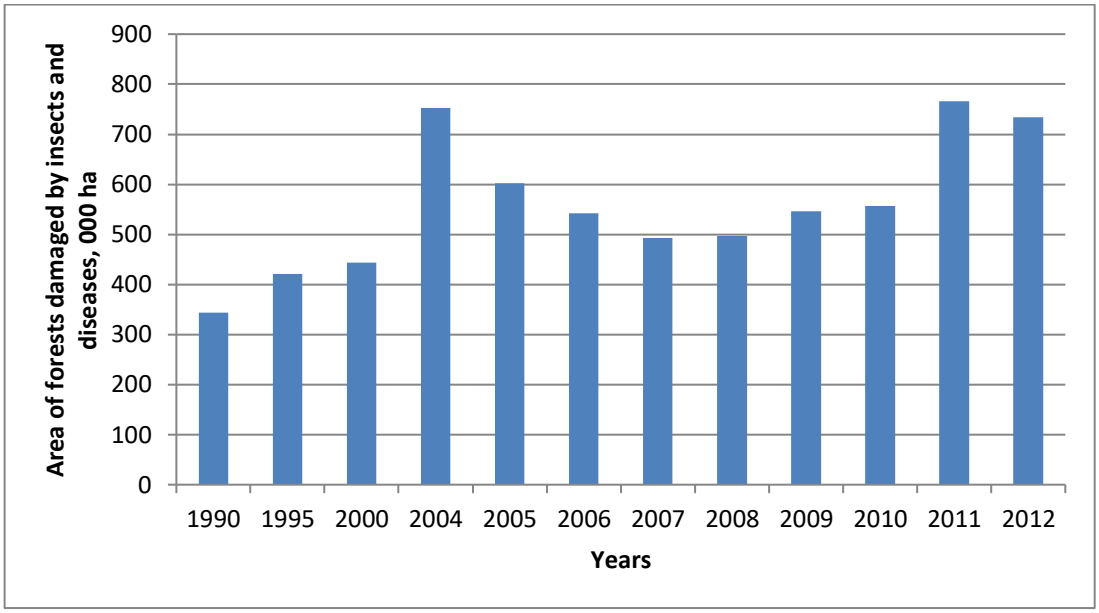


Fig. 6 Area of forests of Ukraine damaged by insects and diseases, 1000 ha (Statistical yearbook, 2013)

That means that near 7.8% of Ukrainian forests were damaged by insect and diseases in 2004. Almost same level were reached 7 years after in 2011 and 2012 (765.8 and 733.9 accordingly). Between maximums in 2004 and 2011, from 500 to 600 thousands ha annually damaged forests reported. In regional aspect largest impacted by pests areas of forests are in Kyivska (103-112 thou ha), Chernihivska (74-141), Kharkivska (45-59) and Ivano-Frankivska (52-62).

Impact of pests on main tree species of Ukraine quite different. Accordingly to the results of pest monitoring based on forest inventory database in average up to 4.5% of oak forests, 6-7% of spruce forests and 3-4% of pine forests are damaged by pests (Ustskiy, 2011). Analysis of dynamic of level of damage of main species since 2000 shows that most intensive growing of damaged forests occurs in oak forest and spruce forests - in 2.1-2,2 times, while in pine forests - in 1.3-1.4 times.

Factors causes these damage are very different because difference in climate conditions, topography, species and management regime that require more deep analysis. Regarding oak forests main damage related with negative impact of early spring complex of leaf damaged insects that cause defoliation than diseases damage forests impacted initially by insects. Damage of spruce mostly related with historical reasons, in particularly spruce forests were planted 40 50 years ago in inadequate sites by soil capacity to provide proper nutrition and moisture regime also affected recently by climate change. After initial weakening of stands due to abovementioned reasons bark beetle become a main reason of further damage of spruce. Pine stands mostly suffer from root diseases and needles damage insects.

Need to be mentioned that under definition “forests damaged due to impact of insects and diseases” means alive forests with indicators of impact of insects and diseases that followed by decreasing of productivity and dieback of some trees, but whole stands can survive after proper pest management. If certain forests die from impact it will show up as “died forests” in statistics that analysed below. Accordingly to forecasts area of damaged forests will increase after 2014 (Ustskiy, 2010). Regional peculiarities of forest disturbance by pests presented on Figure 7.

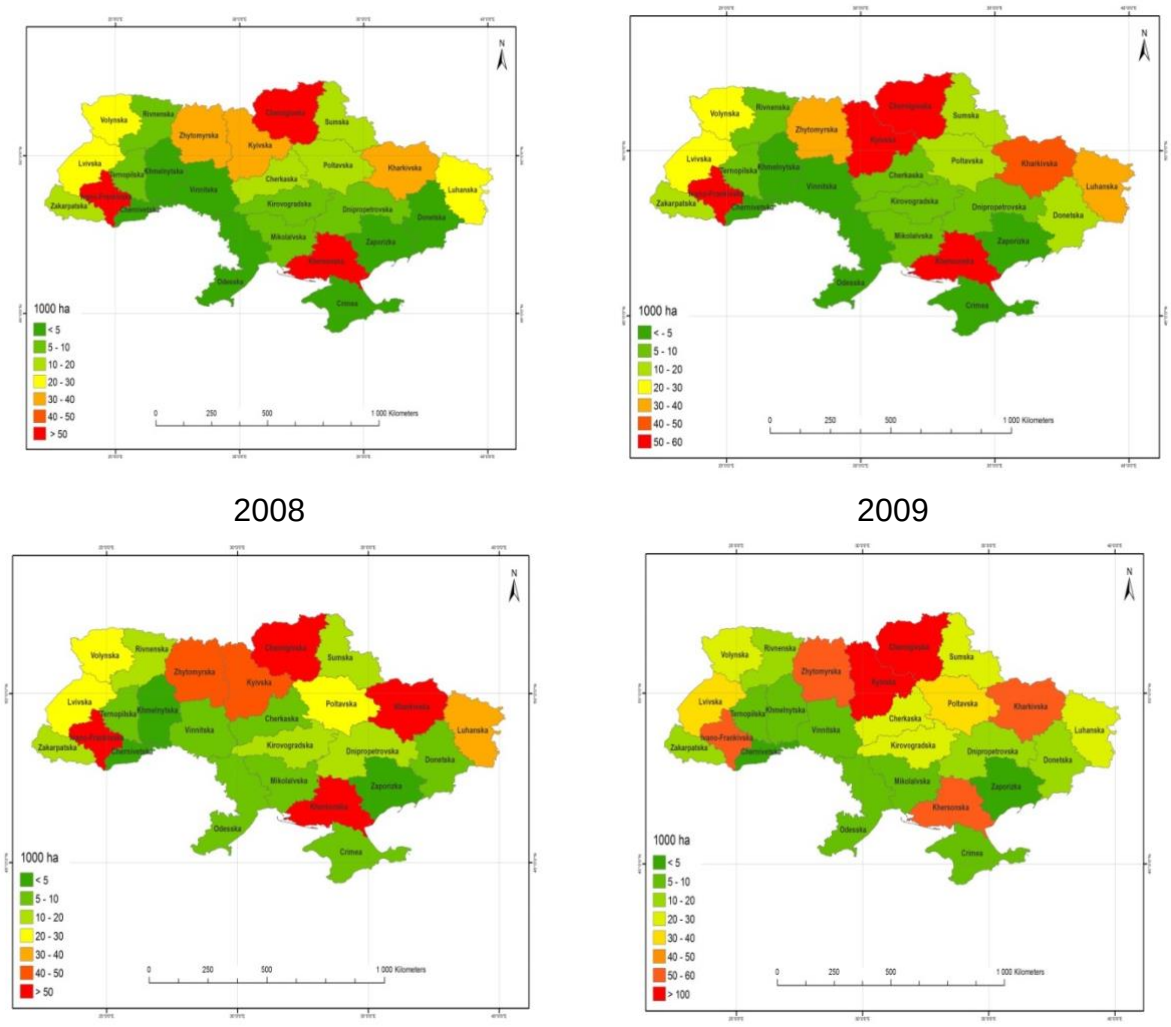


Fig. 7 – Regional and temporal dynamic of forests damaged by pests, thousands ha

Largest areas of forests damage by pests located in Chernigivska (pine), Kharkivska (oak), Khersonska (pine), Ivano-Frankivska (spruce), Kyivska (pine, oak) and Ghytomyrska (pine) oblasts - 40 000 ha and more of totally damaged forests. Another group of oblasts can be characterised as moderate level of damage - - Lvivska, Volynska, Poltavska, Luhanska. In other oblasts damage of forests by pests recognised on areas not more 10-20 thousands ha.

4. Impact of wildland fires on forests of Ukraine

Land-use history and climate change are two global change factors that have worked in concert to increase the risk of catastrophic fire in Ukraine. Area of abandoned and exhausted and thus more fire prone agriculture and forest lands have been permanently increasing during last two decades. Occasional or intentional burning of agricultural and grass lands became a serious factor that impacts local and regional environment thought smoke pollution and through contamination of the atmosphere by “black carbon” particles that migrate with spring winds to the Arctic and stimulate reducing of albedo of ice fields. Only in Ukraine for the period 2003–2012 annual number of fires on croplands reached 5000–40000 with annual area burned 30000–240000 ha. Accordingly to recent estimation (Goldammer et al, 2013) spring fires on croplands of Ukraine generated in different years 38-122 tons annually of “black carbon” emissions.

Failure of a reactor of the Chernobyl Nuclear Power Plant in 1986 lead to radioactive contamination of 60 000 sq. km of forests in Belorussia, Russia and Ukraine. Wildfires became a growing problem in these forests even 27 years after the disaster due to limited forest and fire management, intensive fuel accumulation. Emissions of radionuclides that spreads with smoke from wildfires threatened fire fighters, population and environment in local and in the regional scale. During the period 1993–2010 more than 1034 fires occurred in the Chernobyl Exclusion Zone (ChEZ). Rapid grows of areas designated to biodiversity conservation resulted in increasing of large areas of forests without any silvicultural intervention with high risk of uncontrollable fires. In 2009 fire in Polesskiy Natural Reserve burned up to 900 ha of protected forests.

During analysis of forest fires as forest disturbance factor very special situation with fire statistics in Ukraine need to be taken into account. As national forestry leadership in Ukraine establish a rule when strong financial and administrative sanctions on forestry enterprise where fires occurred especially large fires or big number of fires are implemented, in many cases the enterprises has not been included all fires in fire statistics to keep their records stable or positive. In most cases very large fires with area more than 25 ha usually included in statistics as additional fire forces from Ministry of Emergency join the suppression and it is difficult to hide the fire. It should be noted that there is no significant difference between figures of national statistics on areas of fires in Ukrainian forests and figures of comes from forests manages by SAFRU (Fig. 8). It is related with the fact that best statistics available for forests of SAFRU while fire statistics from forests of other constant users usually absent or inadequate. There are two main sources of data were used for diagram below – internal statistics of SAFRU and official statistics presented in Statistical Yearbook of Ukraine. Detail statistics on dynamic of surface and

crown fires in forests managed by SAFRU presented in Annexes 5-8.

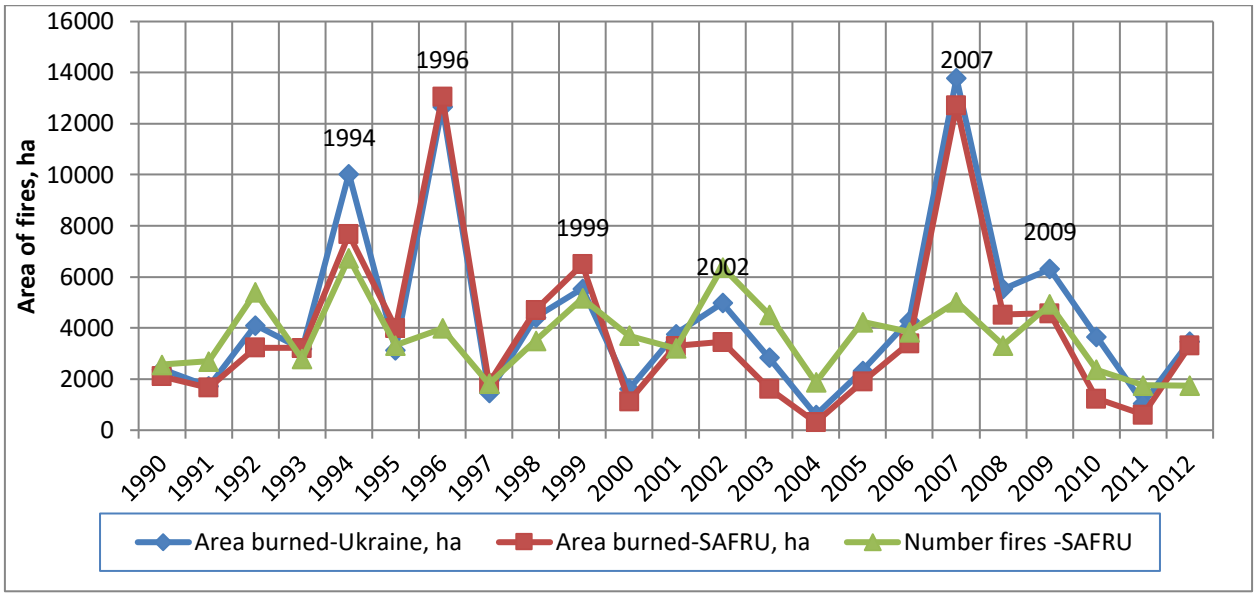


Fig. 8 – Dynamic of area and number of forests fires in Ukrainian forests and forests managed by SAFRU (1990-2012), ha

Area of forests burned annually first of all related with weather conditions and ignition sources. Also important role playing preparedness of fire forces that in general very good correlated with efficiency of forestry system as a whole. During transition period of adaptation of forestry to market condition from 1990 to 1996 area of fires grew up in more than 6 times from 2000 ha annually (1990-1991) to 13061 in 1996. After adaptation of forestry enterprises to market environment they were be able to invest more costs in fire management and so situation stabilized on level 2000-6000 ha during 1997-2006. Also there were no critical fire weather years happened at that period. Changes of top and regional management personal occurred in the beginning of 2007 together with hot summer contributed to highest in latest Ukrainian history area of fires burned in 2007 - 13787 ha. Mostly two large fires contributed - Kherson fire (up to 9000 ha) and Yalta fire (up to 1000 ha).

Comparative analysis of area burned by fires and number of fires shows reducing of effectiveness of fire management in Ukraine as a whole. It is known that number of fires more depends from weather condition and ignition sources. As soon as number and area of fires are similar or close - it is mean that response and preparedness is on high level. Area burned in critical fire years shows effectiveness of fire management and it preparedness. It is clearly could be seen fire years of fire maximum, when number of fires are in the level or previous year while area burned increased essentially – 1994, 1996, 1999, 2007, 2009. Climate changes make very much uncertain length of period between fire maximums - so more attention should be paid by foresters for better preparedness to extreme weather condition. Fires also make significant negative contribution on current growing stock and so future harvesting volumes (Fig. 9).

Table 5 - Regional dynamic of areas of forest fires in Ukraine, 2000–2011, ha

Oblast	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Ukraine	1618	3772	4983	2833	595	2325	4287	13787	5529	6315	3668	1049
Crimea	149	86	58	25	334	75	90	1482	164	46	12	9
Vinnitska	0	8	3	9	0	3	13	13	3	10	3	0
Volynska	110	107	369	257	73	58	1738	24	5	48	35	0
Dnipropetrovska	94	46	98	509	9	186	87	410	305	253	1942	15
Donetska	115	372	121	49	11	140	392	497	217	137	68	27
Zhytomyrska	53	34	1104	164	56	22	24	15	170	1485	101	81
Zakarpatska	51	12	0	22	2	0	5	2	15	9	1	14
Zaporizka	35	103	57	115	4	124	20	162	263	125	37	42
Ivano-Frankivsk	9	0	1	10	1	0	2	7	0	0	0	0
Kyivska	82	46	140	200	70	78	193	245	386	603	192	239
Kirovogradska	70	23	81	49	9	143	11	45	5	35	12	8
Luhanska	147	200	251	65	31	78	316	755	511	1539	518	14
Lvivska	17	0	13	101	4	6	2	7	4	18	10	19
Mikolaïvska	132	1322	252	22	6	58	64	261	83	20	0	13
Odesska	60	42	41	10	8	121	13	161	40	53	1	26
Poltavska	30	31	75	124	5	418	38	42	185	74	16	10
Rivnenska	41	31	257	39	21	16	243	39	35	272	101	168
Sumska	33	55	373	154	25	189	189	160	47	298	123	30
Ternopilska	3	2	1	10	0	0	0	0	0	0	0	3
Kharkivska	18	37	76	38	3	86	43	99	1844	274	182	31
Khersonska	71	895	455	251	43	237	431	8886	257	131	11	139
Khmelnytska	4	1	2	29	25	3	15	12	12	84	24	19
Cherkaska	49	122	145	195	24	51	52	86	43	77	54	40
Chernivetska	4	1	0	5	3	11	1	0	0	5	0	2
Chernigivska	112	104	921	252	93	160	247	203	869	458	178	58

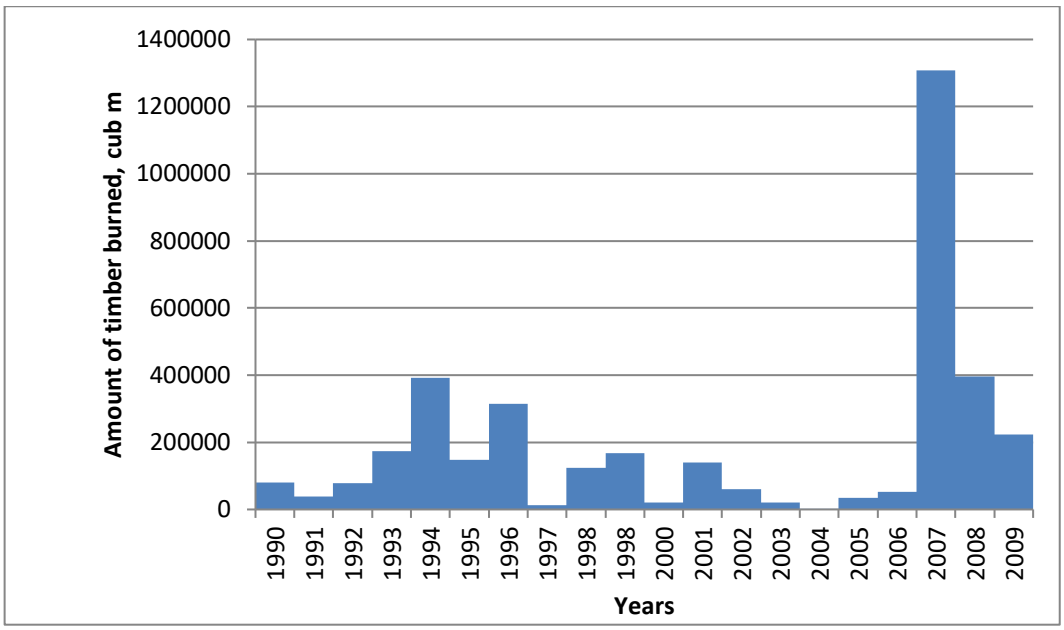
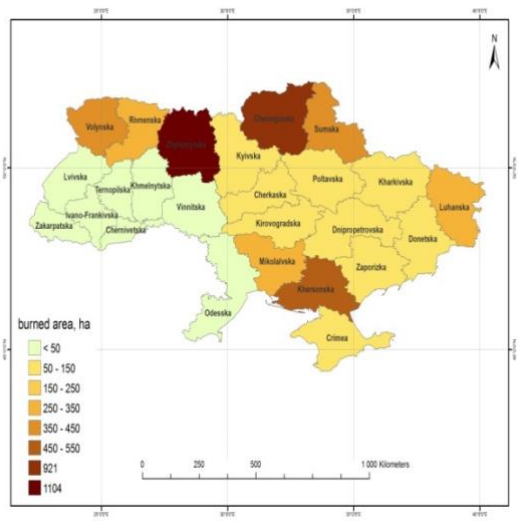
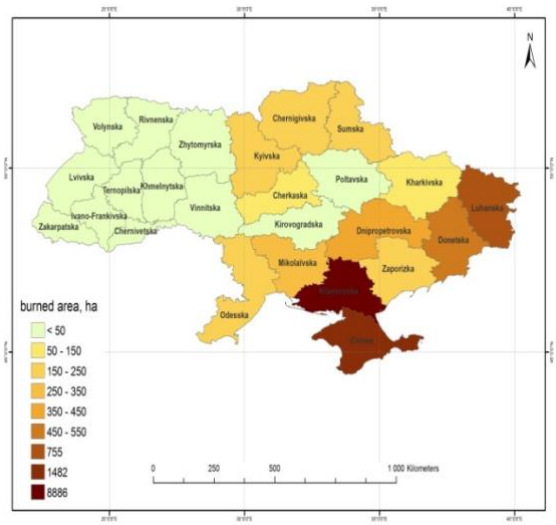


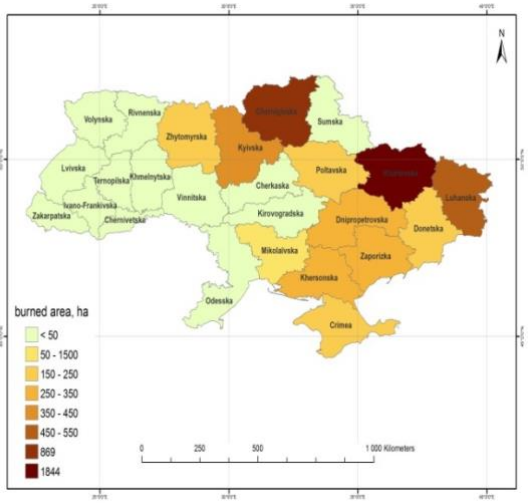
Fig. 9 – Amount of burned and damaged timber due to fires in Ukraine, cub m



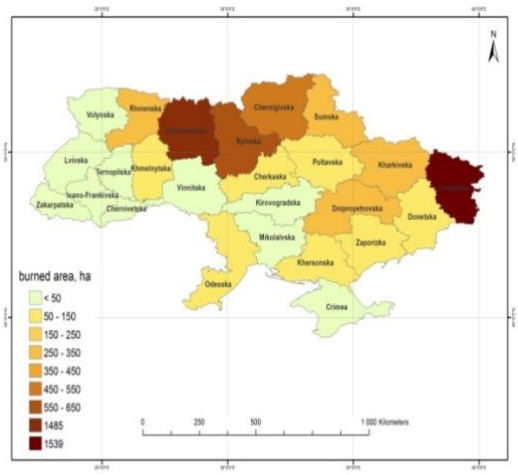
2002



2007



2008



2009

Fig. 10 – Regional dynamic of area of forest fires in years of fire maximum, ha

Amount of timber burned or damaged annually reported between 35 – 400 thousands cub m annually while in year of fire maximum (2007) it reached 1,3 million cub m. Analysis of regional dynamic of burned area shows that Southern, Southern-Eastern and North parts of Ukraine mostly disturbed by fires (Fig. 10). In northern part of Ukraine - Polissia - largest fires happens in Ghytomirska oblast (2002 – 1104 ha, 2009 – 1485 ha), Chernihivska (2002 – 921 ha, 2008 – 869 ha, 2009 – 458 ha), Kyivska (2009 - 603 ha). Unfortunately, statistics as it was mentioned earlier does not fully reflect scale of disturbance. For example, in statistics were not reflected large fire in Rivnenska oblast in 2002 – more 2000 ha that very well could be recognised in Landsat satellite image (Fig. 11). Same happens with big fire in Volyn oblast when almost whole forest ranger district (lisnyctvo) of Kamen-Kashyrskiy forestry enterprise were burned in 2001.

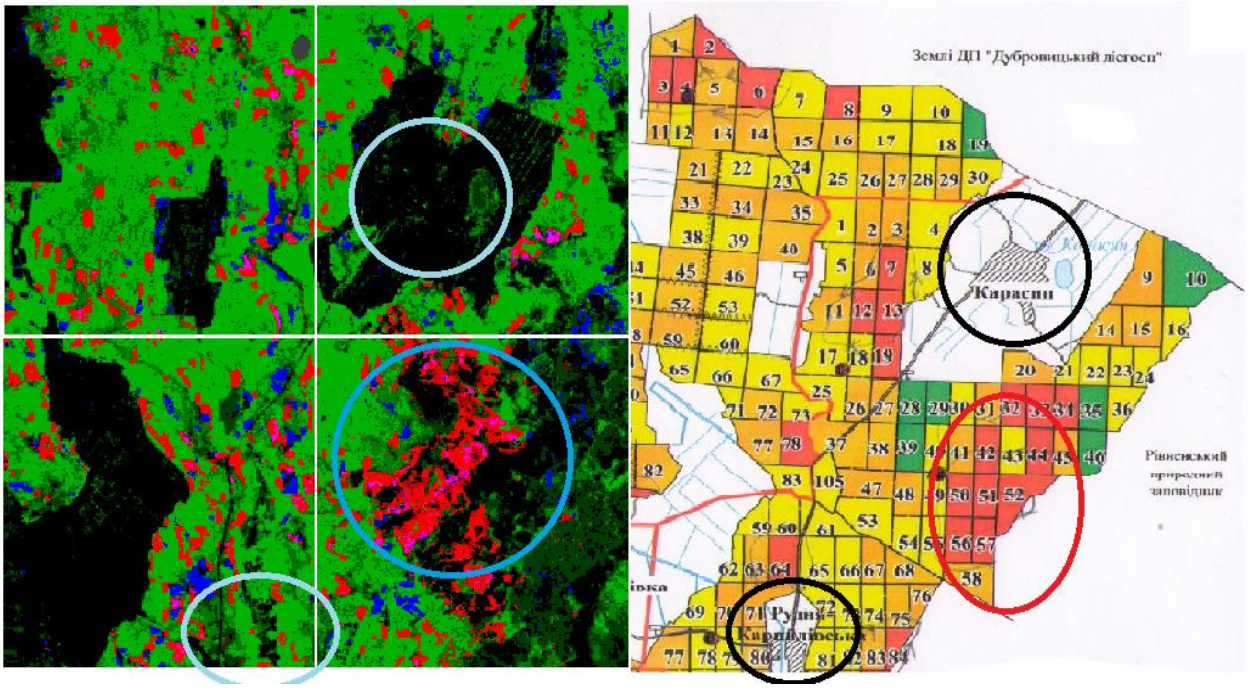


Fig. 11 – Large fires 2002 year in Rivne oblast reflected in Landsat image that were not included in official fire statistics

In Forest Steppe zone large areas of fires were detected in Kharkivska oblast (2008-1844 ha), Sumska oblasts (2002-373 ha). Largest areas and amount of fires occur in the Steppe zone – Kherson oblast (2002 – 455 ha, 2007 – 8886 ha, 2008 – 257 ha), Luganska oblast (2007 – 755 ha, 2008 – 511 ha, 2009 – 1539 ha), Donetska (2007-497 ha), Dnipropetrovska (2007 – 410 ha, 2008 – 305 ha). In other oblasts annual areas of fires reflected in statistics are on level of 100-300 ha.

As fires are an important factor of redistribution of carbon stored in forests it is important to understand share of different types of fires in total area of burned forests that presented in Fig. 12 (National, 2011).

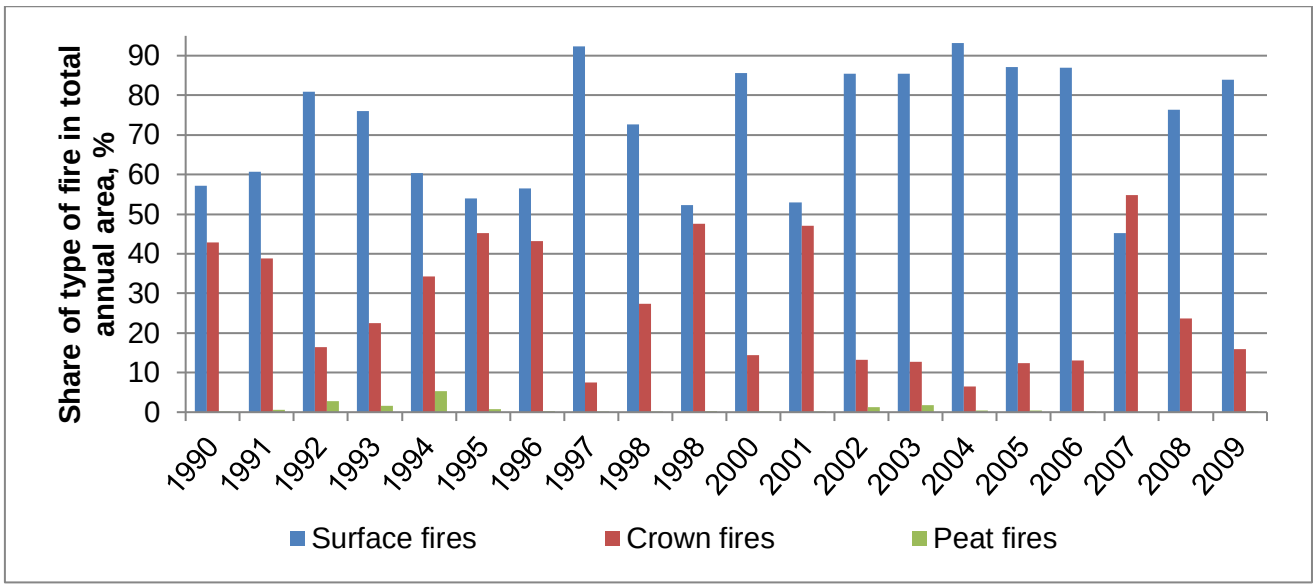


Fig.12 – Dynamic of share of surface, crown and ground fires in total area of forest fires in some years during 1990 – 2009, %

In most cases from 60 to 92% of total fires area burned by surface fires while in some years share of crown fires higher (2007 – 54.8%) than surface fires or near 30-40% (1998, 2001).

5. Total areas of forests died from impact of natural and anthropogenic factors

Accordingly to the official statistics impact of diseases, insects, wildland fires and unfavourable climate condition (windbreaks, snow- and ice breaks, changes of level of underground water) are the main reasons of dying of Ukrainian forests. Since 1990 total area of forests that died annually from abovementioned reasons has been growing from 4020 ha to 20187 ha in 2012 with maximum in 2007 - 29897 ha (Fig. 13).

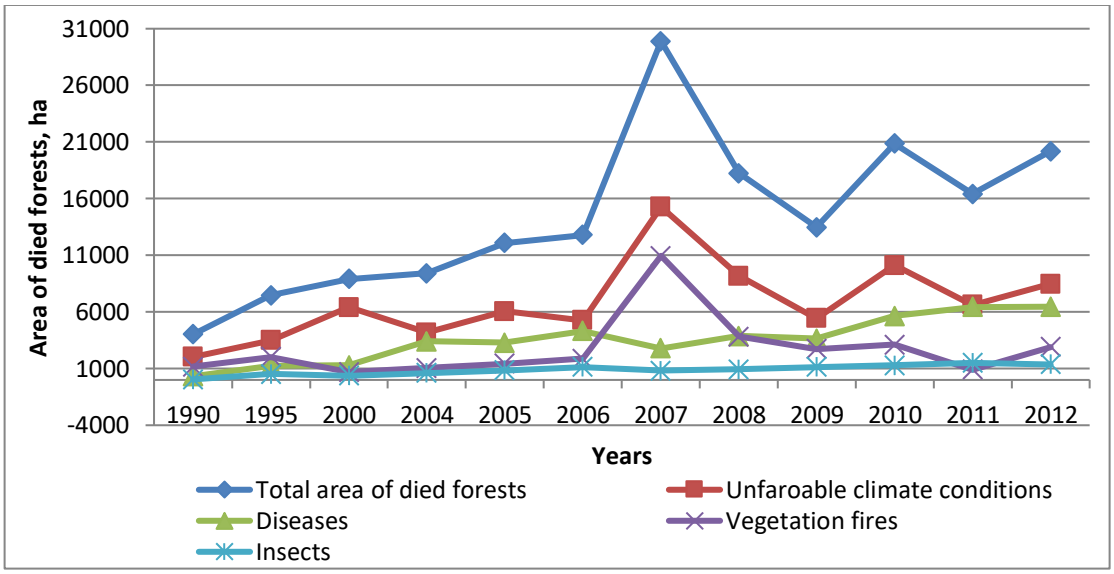


Fig. 13 - Impact of natural disturbances on dynamic of area of died forests in Ukraine, ha

Impact of unfavourable climate conditions, that was reported as most important cause of forest dieback in Ukraine, grew from 2024 ha in 1990 to 8469 ha in 2012. Area of forests died from diseases in 2012 reached 6463, from insects - 1376. Area of burned forests very much vary depends of year: in fire maximum year its reach 11000 ha (2007), but usually stays on level from 1500 to 4000 ha. In terms of regional peculiarities of dieback forests no one region could be characterized as one without dieback of forests as in different years natural or anthropogenic factors cause dieback all over Ukraine (Annexes 10-15).

In the same time some regional peculiarities of dieback of forests could be described. Largest areas of died forests from diseases reported in 2012 in the western part of the country: Trans-Carpathian oblasts (830 ha in 2012), Lviv (107 ha), Khmelnitska oblast (121 ha). In the eastern part only Sumska oblast with 178 ha of died forests reported. Forests died from impact of diseases mostly located in western (Lvivska, Chernivetska, Ivano-Frankivska, Zakarpatska) and northern (Polessie) parts of the country, where from 500 to 1023 ha of forests died annually. In Carpathian region large areas of spruce plantations dying last years, in Polessie main reason of dieback is a root rot of pine. Under term “unfavourable climate conditions” different factors joined in the statistics. Spruce and pine forests died due to windbreaks and changes of level of underground water all over Ukraine: in Rivnaneska (2283 ha in 2012), Luhanska (997), Zakarpatska (545), Khersonska (365), Lvivska (298) and Volynska (523) oblasts. Wildfires causes dieback of pine forests mostly in Polessie and sandy arenas along rivers Dniper and Siverskiy Donets in the south and eastern south parts of Ukraine. Large areas of died forests due to fires reported every year mostly related with large fires events: for example Khersonska oblasts 10955 (2007), Kharkivska - 1651 ha (2008), Chytomyrska (817 ha), Luganska (730 ha) in 2009, Dnipropetrovska oblast 1797 ha in 2010, Khersonska - 2298 ha in 2012. From 448 to 968 ha of annually died forests reported by statistics as due to other reasons.

Conclusions

Total area of Ukrainian forested lands during 2000–2013 has been increased, but different statistical sources gives controversial information about rate of this increasing. This requires special study with use of remote sensing methodology to get actual current forested area.

Clear cuts during final and sanitary cuts continue to be most important disturbance factor for Ukrainian forests, that lead to removal most of tree biomass, destroying forest litter and soil on the area of up to 50 000 ha annually with harvesting up to 13 million cub m of timber. Most intensive it happens on Polessia, Forest-Steppe and Carpathian zones. Shelterwood harvesting, late thinning (after 40 years) and selective sanitary cuts make less essential disturbance with removal 10-20% of timber and partial disturbance of litter during skidding on total area 950,4 thousands ha and distributed regularly all over the country. Share of illegal logging stated officially is on level 24-36 thousands cub m annually, but there is a lot of evidence that illegal logging can be essential (5-10% of total volume of harvested timber) disturbance factor of Ukrainian forests especially in Carpathian region but special study needed for more precise assessment.

Insects and diseases damage forests on area up to 730 thousands ha annually. Mostly this impact resulted in loss of 15-30% of foliage and/or dieback of 10-25% of tress. In case of heavy impact of those factors its lead to dieback of more than 40-50% of trees in stands and so followed by clear or selective sanitary cuts. Forests of Polessia and eastern forests steppe zone most often reported as damaged by pests.

Crown fires lead to full and fast loss of almost all aboveground carbon from forests except carbon in timber that usually decompose in forests or using as a firewood during next after the fire years. In years of fire maximum up to 1.3 million cub m of timber and up to 10 000 ha burned while usual level - from 0.2 to 0.4 million cub m and 2-4 thousands ha. In Ukraine prevailing surface fires that burn forest litter on area up to 4-6 thousands ha annually and usually lead to dieback of 15-40% trees that lead to clear sanitary cuts of all trees on burned forests in a 2-4 years. Special study case may be executed for comparing official fire statistics data with data obtained by Terra and Aqua.

Total area of annually died due to different reasons of forests last years was at level 16-21 thousands ha. Among this area direct impact of unfavourable climate events (windbreaks, snowfall, ice break) 8.4-10.1 thousands ha, crown fires 2,5-2,9 thousands ha diseases (5.6-6.4) are most important.

Summarizing, could be concluded that in total annually 60-70 thousands ha of forests of Ukraine (0.7% from total forested area) disturbed essentially with total loss of aboveground carbon and partial loss of soil carbon and up to 1.6 million ha (17.4%) disturbed partially. More precise assessment of illegal logging could change this assessment essentially.

Annexes

Annex 1

Dynamic of forest lands accordingly to the National Cadaster of anthropogenic emissions (2011), 2001-2009

Oblast	2001	2002	2003	2004	2005	2006	2007	2008	2009
Crimea	282,6	284,2	284,5	284	284,4	284,4	283,2	282,1	280,2
Vinnitska	333,2	333,1	332,8	332,8	332,4	331,5	330,1	328,7	327,3
Volynska	635	636,3	636,2	636,1	636,5	635,3	633,1	632,8	632,3
Dnipropetrovska	119,2	116,7	116,1	116,1	115,9	115,2	114,6	113,7	111,3
Donetska	154,2	154	153,9	154	154	153,5	153,3	152,5	150,5
Zhytomyrska	982,4	983	983,3	984,3	990,2	1004	1004,2	1003,3	1006,3
Zakarpatska	639,7	637,9	637,7	637,8	637,7	637,7	637,7	637,7	637,6
Zaporizka	37,5	43,3	48,3	48,9	51,7	51,2	51,1	50,1	48,1
Ivano-Frankivska	589,2	590,5	590,6	589,4	587,7	587,7	587,6	587,2	587
Kyivska	613	613	613,2	613,5	614,7	613,6	613,3	612	611,4
Kirovogradska	117,6	118,7	118,4	119,7	119,4	119	118,2	117,3	115
Luhanska	269,7	268,8	268,1	267,2	265,6	262,1	260,1	258	249,4
Lvivska	597,5	598,3	605,3	604,9	604,8	604,2	603,6	603,4	603,4
Mikolaïvska	57,4	57,6	57,6	57	56,7	53,4	55,2	53,6	50,8
Odesska	141,4	144,7	144,7	144	143,8	142,8	142,3	137,3	134,2
Poltavska	214	226,4	225,6	225,7	225,5	224,2	223,2	222	220,3
Rivnenska	734,7	734,5	734,6	734,3	734,1	734,5	732,3	729,9	729,9
Sumska	409,4	409,8	410,3	410,1	410,3	409,4	409,2	407,3	406,9
Ternopilska	184,2	184,1	184,1	184,3	184,4	184	183,4	182,2	181,8
Kharkivska	343,2	352,1	352,3	353,1	352,9	351,7	351,3	351,4	349,5
Khersonska	100	100,4	101,5	100,8	100,4	100,1	99,7	90,8	91,3
Khmelnytska	258,5	258,4	258,3	258,4	259	258,4	258,1	256,6	255,7
Cherkaska	310,3	307,4	307,6	307,7	307,3	306,8	305,9	305,3	304,6
Chernivetska	222,5	222,3	222,2	222	222,2	222,8	222,7	222,5	222,4
Chernigivska	644,7	643,9	644,6	645,7	646,7	646,3	645,3	644,5	643,5
Ukraine	8991,2	9019,3	9031,8	9031,7	9038,2	9033,5	9018,5	8982,3	8950,3

Annex 2

Harvesting of timber in Ukraine during final harvesting, thinning, sanitary and other cuts, 000 cub m

	Type of harvesting		
Year	**Total harvesting**	**Final harvesting**	**Thinning, sanitary, others**
1990	14127,8	5755	8372,8
1991	12061	5267	6794
1992	12514,2	5047	7467,2
1993	12497,2	4761	7736,2
1994	11782,5	4891	6891,5
1995	11651,3	4574	7077,3
1996	13782	4375	9407
1997	13546,7	4761	8785,7
1998	11521,1	5138,5	6382,6
1999	11244,2	4879,7	6364,5
2000	12735,9	5236,4	7499,5
2001	13365,4	5507,3	7858,1
2002	14692,1	5833	8859,1
2003	15953,3	6589,4	9363,9
2004	17300,4	6962,1	10338,3
2005	17124,3	6918,4	10205,9
2006	17759,8	7330,9	10428,9
2007	19013,9	7616,3	11397,6
2008	17687,5	7528,2	10159,3
2009	15876,5	7211,8	8664,7
2010	18065	7767,4	10297,6
2011	19746	8647,5	11098,5
2012	19763,6	8433,2	11330,4

Annex 3

Total harvesting of commercial timber by regions, 1000 m3

Region	2000	2005	2007	2008	2009	2010	2011
Ukraine	**11261,7**	**15244,3**	**16884,3**	**15723,7**	**14221,4**	**16145,6**	**17510,3**
Crimea	54,4	60,1	63,0	71,9	65,5	59,3	64,7
Vinnitska	438,2	624,7	722,5	690,2	639,6	667,3	667,2
Volynska	641,8	877,1	1023,2	907,3	849,3	976,7	974,9
Dnipropetrovska	54,4	48,6	47,8	61,2	36,5	44,6	139,1
Donetska	36,5	51,6	62,6	62,8	66,2	81,2	99,0
Zhytomyrska	1356,3	1977,7	2206,4	2157,3	2099,6	2444,1	2684,9
Zakarpatska	906,7	1032,3	1117,2	953,4	905,2	1003,7	1157,4
Zaporizka	21,6	18,0	21,4	23,2	24,9	28,0	27,0
Ivano-Frankivska	518,0	784,6	950,5	864,7	839,3	923,2	1005,1
Kyivska	950,1	1287,8	1270,3	1210,2	999,5	1274,7	1391,2
Kirovogradska	101,2	213,8	213,3	202,7	181,0	182,8	205,9
Luhanska	205,6	152,4	182,2	181,7	167,4	230,3	208,2
Lvivska	774,1	1036,2	1244,7	1165,9	960,4	1106,8	1254,4
Mikolaïvska	34,4	36,3	45,3	33,5	34,1	33,9	33,8
Odesska	71,5	136,7	124,6	100,5	88,3	77,0	78,9
Poltavska	386,7	328,1	333,0	324,7	315,8	367,1	381,1
Rivnenska	816,0	1191,3	1341,9	1320,6	1256,8	1409,5	1469,1
Sumska	640,2	902,9	977,6	954,9	854,8	962,2	1042,8
Ternopilska	243,7	260,5	288,6	262,5	223,2	247,2	293,8
Kharkivska	406,9	578,3	519,8	451,1	422,7	421,4	463,0
Khersonska	68,6	146,5	370,2	155,3	130,5	127,0	95,5
Khmelnytska	520,4	718,6	665,3	590,2	557,2	576,1	616,7
Cherkaska	406,9	567,2	616,3	588,2	544,8	608,0	617,7
Chernivetska	569,3	804,3	920,9	866,1	821,8	899,9	963,9
Chernigivska	938,0	1284,9	1451,8	1400,1	1051,5	1237,9	1412,4

Annex 4

Total area of forests damaged by insects and diseases by regions , 000 ha

Region	2007	2008	2009	2010	2011	2012
Ukraine	492,6	510,0	192,1	557,4	351,0	229,3
Crimea	4,9	4,6	4,1	7,1	0,9	0,9
Vinnitska	3,5	4,7	7,2	7,3	6,2	3
Volynska	23,7	22,4	9,8	25,7	9,5	8,5
Dnipropetrovska	7,3	7,4	4,5	10,3	4,2	6,7
Donetska	4,5	11,7	1,3	5,7	3,5	2,5
Zhytomyrska	39,4	37,1	6,2	42,8	14,8	12,8
Zakarpatska	13,7	14,5	7,1	14,1	7,7	8,7
Zaporizka	3,1	2,5	0,5	2,5	0,3	1,4
Ivano-Frankivska	62,5	52,4	34,2	57,6	32,6	33,2
Kyivska	37,4	50,6	7,9	44,8	60,5	11,4
Kirovogradska	9,3	9,2	0,9	15,5	1,1	0,8
Luhanska	27,5	32,7	23,5	31,6	17,6	17,3
Lvivska	24,9	23,4	19,2	28,7	23,3	26,1
Mikolaïvska	6,0	5,6	0,9	6,3	1,2	1,1
Odesska	3,4	3,8	0,2	9,6	3,2	7,8
Poltavska	17,0	19,5	3,1	28,9	9,4	7,2
Rivnenska	8,4	9,5	4,9	11,2	4,4	6,9
Sumska	12,6	19,7	12,3	19,2	10,1	8,4
Ternopilska	5,5	6,1	5,9	7,6	6,4	6,5
Kharkivska	37,8	45,4	12,7	58,6	15,9	17,2
Khersonska	58,3	60,0	15,0	52,6	36,9	25,8
Khmelnytska	3,8	3,4	3,3	5,0	5,7	3,6
Cherkaska	12,3	6,4	0,0	5,8	15,0	3,1
Chernivetska	1,7	1,6	0,7	1,9	0,4	0,2
Chernigivska	62,5	54,7	6,8	55,4	58,0	6,9

Annex 5

Fire statistics in forests of Ukraine and forests managed by SAFRU

Indicators / Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Area of fires (Ukraine), ha	2389	1717	4101	3178	10030	3137	12671	1467	4418	5542	1618
Area of fires (SAFRU), ha	2114	1669	3235	3214	7667	3995	13061	1835	4706	6494	1132
Number of fires (Ukraine)	2714					3758					3696
Number of fires (SAFRU)	2567	2702	5402	2789	6743	3324	3991	1818	3509	5169	3696
Average area of fire, ha (SAFRU)	0,82	0,62	0,60	1,15	1,14	1,20	3,27	1,01	1,34	1,26	0,31
Average area of fire, ha (Ukraine)	0,88					0,83					0,44

Indicators / Years	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Area of fires (Ukraine), ha	3772	4983	2833	595	2325	4287	13787	5529	6315	3668	1049	3479
Area of fires (SAFRU), ha	3295	3458	1629	306	1900	3407	12713	4521	4575	1239	612	3311
Number of fires (Ukraine)				1876	4223	3842	6100	4042	7036	3240	2526	2163
Number of fires (SAFRU)	3205	6383	4527	1876	4231	3842	5024	3316	4922	2368	1761	1743
Average area of fire, ha (SAFRU)	1,03	0,54	0,36	0,16	0,45	0,89	2,53	1,36	0,93	0,52	0,35	1,90
Average area of fire, ha (Ukraine)				0,32	0,55	1,12	2,26	1,37	0,90	1,13	0,42	1,61

Annex 6

Areas of crown and surface wildfires and volumes of burned timber in Ukraine during 1990-2009

Year	Area of forests burned, ha			Timber burned and damaged by fires, cub m
	Surface fires	Crown fires	Peat fires	
1990	1366	1022	1	79909
1991	1042	665	10	38252
1992	3318	672	111	77758
1993	2415	712	51	174499
1994	6061	3432	537	391999
1995	1695	1416	26	147647
1996	7163	5466	42	315088
1997	1355	110	2	11850
1998	3208	1208	2	123360
1998	2896	2632	14	166721
2000	1386	232	2	20647
2001	1992	1770	3	139604
2002	4245	657	64	59625
2003	2409	359	49	20071
2004	536	37	2	1944
2005	2057	293	9	34260
2006	3729	557	1	53119
2007	6238	7549	–	1308223
2008	4218	1311	–	395257
2009	5300	1010	5	223764

Annex 7

Dynamics of areas of surface fires in forests of SAFRU, ha

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Crimea	141,0	73,0	57,0	25,0	32,0	8,8	83,7	901,9	131,9	42,2	11,5
Vinnitska	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,3
Volynska	83,0	62,0	322,0	227,0	39,3	0,4	1570,9	11,1	1,4	12,4	2,8
Dnipropetrovska	48,0	41,0	69,0	157,0	9,0	29,0	79,8	234,3	225,0	136,1	139,9
Donetska	17,0	241,0	193,0	56,0	11,4	15,5	341,9	420,6	179,6	102,7	41,8
Zhytomyrska	25,0	9,0	484,0	77,0	12,8	0,0	6,0	10,1	47,5	951,6	55,2
Zaporizka	30,0	62,0	51,0	77,0	3,9	25,1	18,6	128,8	206,6	127,0	33,9
Kyivska	29,0	28,0	54,0	65,0	27,2	0,0	41,9	33,7	84,7	207,7	81,2
Kirovogradska	65,0	23,0	81,0	49,0	4,7	0,0	13,3	44,6	4,4	35,9	12,1
Luhanska	56,0	160,0	228,0	66,0	25,4	9,2	250,2	482,4	425,3	963,5	388,4
Lvivska	2,0	0,0	1,0	10,0	0,0	0,0	1,8	6,1	2,0	2,7	0,6
Mikolaïvska	97,0	354,0	134,0	22,0	5,6	6,2	59,0	158,4	71,3	18,7	0,7
Odesska	59,0	20,0	32,0	9,0	8,4	13,0	12,6	143,1	39,4	41,9	0,7
Poltavska	23,0	14,0	43,0	41,0	1,8	110,3	24,4	24,0	61,6	40,7	4,8
Rivnenska	18,0	14,0	163,0	6,0	2,1	0,0	59,2	11,5	6,6	92,2	3,4
Sumska	6,0	20,0	197,0	24,0	18,4	2,9	28,0	45,2	4,8	32,2	31,8
Ternopilska	2,0	0,0	1,0	7,0	0,5	0,0	0,0	0,0	0,0	1,7	0,0
Kharkivska	13,0	20,0	24,0	22,0	1,2	2,0	34,1	82,9	1261,9	206,7	146,9
Khersonska	68,0	241,0	274,0	142,0	24,2	51,3	286,3	2199,0	240,2	146,6	9,5
Khmelnytska	4,0	1,0	2,0	8,0	3,6	0,0	1,9	7,4	1,4	11,2	5,6
Cherkaska	22,0	81,0	126,0	144,0	412,9	3,9	25,8	77,9	37,2	67,1	44,6
Chernigivska	55,0	63,0	405,0	89,0	29,0	0,0	73,1	35,8	360,4	257,5	18,2
Zakarpatska	34,0	12,0	0,0	10,0	0,9	0,0	0,0	1,5	0,0	8,2	0,6
Ivano-Frankivsk	4,0	0,0	1,0	2,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Chernivetska	4,0	1,0	0,0	5,0	0,0	0,0	0,9	0,0	0,0	4,9	0,0
	941,0	1568,0	3055,0	1355,0	41568,1	285,0	3023,0	5200,1	3411,6	3623,5	1044,0

Annex 8

Dynamics of areas of crown fires in forests of SAFRU, ha

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Crimea	8	13	1		1,8	61,9	6,4	292,2	14,8	4,0		
Vinnitska	0	0	0			0,4						
Volynska	1	0	14	5	2,4	48,4	18,0			0,0		
Dnipropetrovska	46	3	10	41		157,0	7,2	109,6	80,3	34,0	44,00	
Donetska	10	118	16	3		125,1	85,9	51,2	18,7	3,6	5,42	
Zhytomyrska	0	0	26	4		17,0		0,0		106,7		
Zaporizka	5	41	6	38	0,5	99,1	1,2	33,3	55,9	5,0	3,23	3,72
Kyivska	1	0	5	3	0,1	46,9	4,0		5,0	126,1		
Kirovogradska	5	0	0			142,0				0,0		
Luhanska	25	41	38	1	5,6	70,1	91,6	272,5	87,4	576,1	128,63	0,35
Lvivska	0	0	0			5,9		0,8		0,0		
Mikolaïvska	35	949	90	1	0,1	51,6	4,8	104,4	13,0	1,8		0,80
Odesska	1	22	9	1		107,9	1,1	17,5	1,2	10,8		
Poltavska	1	0	15	21		298,5		2,0	97,0	10,0		
Rivnenska	0	0	0			3,1	1,2	1,6	0,3	4,5		3,20
Sumska	0	0	0			53,8	4,7	1,6		0,0		
Ternopilska	0	0	0							0,0		
Kharkivska	0	3	1	2		48,6	0,5	4,0	560,8	8,8	8,65	
Khersonska	3	494	137	113	18,6	177,4	149,9	6550,8	26,8	10,0		40,92
Khmelnytska	0	0	0		4	1,6				0,0		
Cherkaska	0	9	3	41	0,3	43,7	7,4	5,3	2,2	1,9	4,05	2,80
Chernigivska	0	0	11		2	41,5			138,0	0,0		
Zakarpatska	7	0	0			0,1				0,0		
Ivano-Frankivsk	1	0	0									
Chernivetska	0	0	0			10,8				0,0		
Total SAFRU	191,0	1727,0	403,0	274,0	36,2	1622,4	383,9	7513,2	1109,6	951,5	195,2	52,4

Annex 9

Impact of natural disturbances on dynamic of area of died forests in Ukraine, ha

Indicator / cause	Years											
	1990	**1995**	**2000**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Total area of died forests	4020	7468	8908	9418	12085	12795	29897	18242	13469	20864	16414	20187
Unfavourable climate conditions	2024	3484	6421	4159	6064	5249	15272	9166	5443	10113	6604	8469
Diseases	323	1252	1278	3420	3294	4329	2793	3883	3628	5632	6428	6463
Vegetation fires	1157	2031	696	1051	1437	1864	10955	3819	2727	3127	909	2915
Insects	48	536	388	598	860	1129	821	926	1146	1295	1505	1376

Annex 10

Temporal and spatial distribution of areas of died forests due to impact of natural and anthropogenic factors, ha

Oblast	2007	2008	2009	2010	2011	2012
Rivnenska	1925	1731	1736	2543	2170	2703
Khersonska	10315	4803	104	612	297	2663
Zakarpatska	1726	1207	1424	1744	1882	2138
Lvivska	1003	709	638	1469	1954	1453
Luhanska	4854	965	2367	3040	1061	1361
Volynska	1373	719	773	923	1095	1304
Chernivetska	623	579	682	767	1071	1282
Zhytomyrska	462	667	1135	727	944	1123
Odesska	1947	267	266	1727	269	1052
Ivano-Frankivsk	1389	981	962	1172	1020	1002
Chernigivska	377	719	329	336	326	772
Cherkaska	202	170	170	430	414	508
Sumska	127	109	132	238	309	476
Kirovogradska	468	546	420	376	515	437
Khmelnytska	387	408	335	177	241	365
Kyivska	257	405	336	497	479	321
Donetska	523	141	377	1124	1334	249
Vinnitska	168	85	85	108	193	242
Dnipropetrovska	304	263	96	1797	194	228
Ternopilska	105	117	99	113	192	181
Mikolaïvska	424	145	154	250	101	140
Poltavska	54	235	206	249	97	56
Kharkivska	328	1892	441	148	84	43
Zaporizka	56	113	36	8	4	37
Crimea	431	130	107	132	1	20

Annex 11

Regional distribution of forests died due to impact of insects, ha

Oblast	Years					
	2007	2008	2009	2010	2011	2012
Ukraine	821	926	1146	1295	1505	1376
Zakarpatska	366	512	691	782	793	830
Sumska	-	-	-	11	93	178
Khmelnytska	15	6	14	36	63	121
Lvivska	102	76	143	92	139	107
Volynska	-	-	-	-	-	66
Cherkaska	7	25	12	16	10	20
Kyiv	98	91	45	176	168	17
Chernigiv	-	28	4	11	4	12
Mykolaiv	3	-	-	-	28	6
Ghytomyr	2	3	-	7	12	3
Chernivtsi	119	10	3	4	16	1
Crimea	60	-	1	-	-	-
Vinnitsa	-	-	-	-	-	-
Dnipropetrovsk	-	-	-	-	-	-
Donetsk	-	-	-	91	141	-
Zaporigska	-	-	-	-	-	-
Ivano-Frankivsk	-	-	48	22	15	-
Kirovograd	-	-	-	-	-	-
Luhansk	11	-	2	-	-	-
Odessa	-	-	-	-	-	-
Poltava	-	-	-	-	-	-
Rivne	-	-	-	2	-	-
Ternopil	-	-	-	-	-	-
Kharkiv	3	159	183	-	-	-
Kherson	-	-	-	-	-	-

Annex 12

Regional distribution of forests died due to impact of diseases, ha

Region	2007	2008	2009	2010	2011	2012
Ukraine	2793	3883	3628	5632	6428	6463
Lvivska	550	460	324	1055	1554	1023
Chernivetska	46	313	310	362	433	713
Ivano-Frankivsk	294	619	636	884	736	705
Zakarpatska	142	237	296	430	594	703
Volynska	388	400	456	649	736	652
Zhytomyrska	251	256	190	339	419	494
Rivnenska	321	320	415	378	296	416
Kirovogradska	186	477	397	360	500	402
Odesska	106	86	78	225	127	292
Kyivska	17	89	54	191	172	162
Cherkaska	12	43	25	105	162	152
Vinnitska	84	68	72	93	156	148
Ternopilska	91	109	96	111	183	140
Luhanska	34	68	61	50	77	134
Khmelnytska	35	69	51	23	44	105
Chernigivska	116	82	45	63	47	84
Sumska	35	64	31	40	87	65
Mikolaïvska	35	29	-	33	30	56
Kharkivska	-	2	6	1	8	12
Donetska	-	-	-	-	-	3
Dnipropetrovska	-	-	1	-	3	2
Zaporizka	14	9	-	-	-	-
Poltavska	36	77	84	240	64	-
Khersonska	-	-	-	-	-	-

Annex 13

Regional distribution of forests died due to impact of unfavourable climate conditions, ha

Oblast	2007	2008	2009	2010	2011	2012
Ukraine	15272	9166	5443	10113	6604	8469
Crimea	5	-	26	63	-	18
Vinnitska	79	8	3	-	27	21
Volynska	743	288	229	257	359	523
Dnipropetrovska	5	20	-	-	12	59
Donetska	434	122	322	989	1181	219
Zhytomyrska	95	167	93	56	133	182
Zakarpatska	1163	440	418	469	421	545
Zaporizka	-	-	-	3	-	4
Ivano-Frankivska	1087	362	278	266	269	280
Kyivska	79	24	18	40	5	118
Kirovogradska	255	66	11	-	2	28
Luhanska	4261	381	1477	2408	899	997
Lvivska	349	170	151	314	223	298
Mikolaïvska	194	40	129	104	39	66
Odesska	1750	178	177	1492	142	760
Poltavska	-	53	108	9	-	56
Rivnenska	1585	1390	1151	2147	1838	2283
Sumska	66	17	78	150	23	188
Ternopilska	14	8	3	2	9	41
Kharkivska	273	80	118	12	50	-
Khersonska	1723	4677	4	606	156	365
Khmelnytska	337	333	258	118	134	139
Cherkaska	160	41	110	230	219	321
Chernivetska	458	207	244	262	292	344
Chernigivska	157	37	37	113	171	614

Annex 14

Regional distribution of forests died due to impact of wildland fires, ha

Region	2007	2008	2009	2010	2011	2012
Ukraine	10955	3819	2727	3127	909	2915
Crimea	366	30	10	1	-	2
Vinnitska	-	2	-	-	10	15
Volynska	242	31	75	17	-	17
Dnipropetrovska	295	243	94	1797	6	90
Donetska	89	5	15	5	4	2
Zhytomyrska	114	153	817	217	238	188
Zakarpatska	50	13	7	1	7	19
Zaporizka	42	104	36	5	4	33
Ivano-Frankivska	8	-	-	-	-	-
Kyivska	42	201	214	88	83	20
Kirovogradska	27	3	12	16	13	7
Luhanska	548	429	730	553	38	82
Lvivska	2	-	1	8	5	13
Mikolaïvska	192	60	2	1	4	3
Odesska	78	3	11	10	-	-
Poltavska	18	105	14	-	-	-
Rivnenska	19	21	170	16	32	4
Sumska	25	20	23	27	102	39
Ternopilska	-	-	-	-	-	-
Kharkivska	45	1651	116	130	24	28
Khersonska	8592	126	53	6	105	2298
Khmelnytska	-	-	12	-	-	-
Cherkaska	23	39	21	65	23	13
Chernivetska	-	-	-	-	-	-
Chernigivska	104	567	243	110	70	31

Annex 15

Dieback of forests of Ukraine due to other reasons, ha

Regions	2008	2009	2010	2011	2012
Ukraine	448	525	697	968	964
Crimea	100	70	68	1	-
Vinnitska	7	10	15	-	58
Volynska	-	13	-	-	46
Dnipropetrovska	-	1	-	173	77
Donetska	14	40	39	8	25
Zhytomyrska	88	35	108	142	256
Zakarpatska	5	12	62	67	41
Zaporizka	-	-	-	-	-
Ivano-Frankivska	-	-	-	-	17
Kyivska	-	5	2	51	4
Kirovogradska	-	-	-	-	-
Luhanska	87	97	29	47	148
Lvivska	3	19	-	33	12
Mikolaïvska	16	23	112	-	9
Odesska	-	-	-	-	-
Poltavska	-	-	-	33	-
Rivnenska	-	-	-	4	-
Sumska	8	-	10	4	6
Ternopilska	-	-	-	-	-
Kharkivska	-	18	5	2	3
Khersonska	-	47	-	36	-
Khmelnytska	-	-	-	-	-
Cherkaska	22	2	14	-	2
Chernivetska	49	125	139	330	224
Chernigivska	5	-	39	34	31

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