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Wildfires and Human Security
Fire Management on Terrain Contaminated by Radioactivity, Unexploded Ordnance (UXO) and Land Mines

Report of an Advanced Seminar held in Kyiv / Chernobyl, Ukraine, 6-8 October 2009

Rationale and Background: Threats Arising from Wildfires burning on Contaminated Territories

In several countries of Eurasia forests and other lands are contaminated by various types of industrial chemical and radioactive pollution and residuals of armed conflicts, e.g. unexploded ordnance and landmines. Wildfires occurring in such contaminated terrain are resulting in secondary damages, such as chemical and radioactive air pollution and explosion of unexploded ordnance (artillery grenades, bombs) and landmines on active or abandoned mined areas.

The territories most affected by radioactive pollution have been contaminated by the consequences of the disaster on the Chernobyl Nuclear Power Plant in 1986. Wildfires burning on contaminated terrain in the Chornobyl Exclusion zone in Ukraine, in Belarus or in Russia result in lifting of radionuclides deposited on vegetation and organic layers and their uncontrolled emission and fallout.

Unexploded Ordnance (UXO) is found on several hundred thousands hectares of forests and other lands throughout Western, Eastern and Southeastern Europe. Remnants of World War I battles along the frontlines of 1917 in Southern Macedonia have repeatedly created problems, e.g. during the fire season of 2007 when more than 70 incidents of explosions of ammunition triggered by forest fires were noted.

In Germany, the battlegrounds of the final phase of World War II in Brandenburg State around Berlin are still highly contaminated by hundreds of thousand of tons of unexploded artillery grenades and bombs. In addition, former military exercise areas and shooting ranges, with some of them dating back to the early 1900s, some established after the war, are posing high risk to civilian populations and especially firefighters.

In Southeast Europe, notably in former armed conflict grounds in former Yugoslavia, active land mines are limiting access, forest and fire management in large areas. In Bosnia and Herzegovina alone more than 200 000 ha of forests are contaminated by land mines. Land mines are also found in the disputed territories in the Southern Caucasus, The combat grounds in and around the Nagorno-Karabakh region represent one of the major UXO-polluted terrains worldwide. During the armed conflict in Georgia in August 2008 a number of forest fires occurred as a consequence of military activities and caused collateral damages in several sites of the country.

Besides radioactive pollution and explosives there are other threats related to environmental pollution and fires, e.g. the lifting of mercury deposited in organic layers by wildfires.

In addition, the air pollution generated by vegetation fire smoke is a phenomenon, which has influenced the global environment and society significantly since the Middle Ages. In the recent decades, increasing application of fire as a tool for land-use change has resulted in more frequent occurrence of extended fire and smoke episodes with consequences on human health and security. Some of these events have been associated with droughts that are attributed to inter-annual climate variability, or possible consequences of regional climate change. In metropolitan or industrial areas, the impacts of vegetation fire smoke may be coupled with the emission burden from fossil fuel burning and other technogenic sources, resulting in

increasing vulnerability of humans. The transboundary effects of VFS pollution are a driving argument for developing international policies; to address the underlying causes for avoiding excessive fire application and to establish sound fire and smoke management practices and protocols of cooperation in wildland fire management at international level.

The Seminar

This seminar addressed specific cases in East, South East Europe and South Caucasus. Examples from Western Europe, the United States and global observations were presented. Participants were briefed and contributed to identify regional problems, expertise, and solutions of managing land and fires in forests and other lands contaminated by radioactivity, unexploded ordnance and land mines. Fire smoke pollution and precautionary/protective measures were also addressed. This first seminar of this kind worldwide gave emphasis on the East / SE Europe / Caucasus region where radioactive contamination, UXO and land mines are rather common.

The seminar had been prepared by a preparatory meeting, which was held at the Ministry of Agriculture, Forestry and Water Economy, Skopje, and was jointly organized by the Global Fire Monitoring Center (GFMC) and the UNISDR Regional Southeast Europe / Caucasus Wildland and Central Asia Wildland Fire Networks. It resulted in recommendations submitted to the Council of Europe, Secretariat of the Euro-Mediterranean Major Hazards Agreement, the Organization for Security and Co-operation in Europe (OSCE) and the Environment and Security Initiative (ENVSEC). These organizations provided some funds for preparing and logistically supporting the seminar, as well as travel costs for participation of delegates from the South Caucasus countries.

Goals of the Seminar

The overall goal and objectives of the Seminar included:

- Inform national decision makers (through attending delegates) of member states of the Council of Europe (particularly member states of the Euro-Mediterranean Major Hazards Agreement), countries belonging to the Economic Commission for Europe (ECE) and / or one of the UNISDR Regional Wildland Fire Networks, as well as international organizations, on the threats of wildfires burning in contaminated terrain
- Exchange experiences on prevention and control of wildfires in contaminated terrain
- Demonstrate the risk of catastrophic consequences of wildfires burning in radioactively contaminated terrain in Ukraine, Belarus and Russia as a consequence of the failure of the Chernobyl nuclear power plant in 1986
- Inform participants on secondary risks of forest fires and other vegetation fires, notably the consequences of smoke pollution on human health and security
- Conclude on the need for action at national and international levels

Organizers, Hosts and Supporters

The seminar was an initiative of the Global Fire Monitoring Center (GFMC) and financially cosponsored by the Council of Europe, Secretariat of the Euro-Mediterranean Major Hazards Agreement, the Organization for Security and Co-operation in Europe (OSCE) and the Environment and Security Initiative (ENVSEC) and organized jointly by the

- Global Fire Monitoring Centre (GFMC) / United Nations University (UNU) in conjunction with the Nations Economic Commission for Europe (UNECE) / Food and Agriculture Organization (FAO) Team of Specialists on Forest Fire [1]
- UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network [2]
- OSCE / ENVSEC

The Seminar was hosted by the National University of Life and Environmental Sciences of Ukraine (NUBiP of Ukraine) and the Ministry of Ukraine of Emergencies and Affairs of Population Protection from

[1] http://www.fire.uni-freiburg.de/ and http://www.fire.uni-freiburg.de/intro/team.html
[2] http://www.fire.uni-freiburg.de/GlobalNetworks/SEEurope/SEEurope.html

the Consequences of Chernobyl Catastrophe, and further supported by Yale University, Global Institute for Sustainable Forestry, U.S.A., and the Chopivsky Family Foundation, U.S.A.

Opening Remarks

Johann G. Goldammer
Global Fire Monitoring Center (GFMC)
on behalf of the UNISDR Wildland Fire Advisory Group

Forest fires and other vegetation fires burning in Greece, Australia and California in 2009 have received worldwide attention. Some of these fires burned with unprecedented intensities – many of them uncontrollable for days and even weeks. Analyses of these fires reveal that changes in regional and local climate as well as recent socio-economic, cultural and land-use changes have resulted in changes of fire regimes and observed increase of severities and impacts of wildfires on societies and environment.

In a number of countries of Europe there are some areas of forests and other lands that are contaminated by various types of industrial chemical and radioactive pollution and residuals of armed conflicts, e.g. unexploded ordnance and landmines. Wildfires occurring in such contaminated terrain are resulting in secondary damages, such as chemical and radioactive air pollution and explosion of unexploded ordnance (unexploded ammunition, e.g. artillery grenades, bombs) and land mines.

The territories most affected by radioactive pollution have been contaminated by the consequences of the failure of the Chernobyl Nuclear Power Plant in 1986. Wildfires burning on contaminated terrain in the Chornobyl Exclusion zone in Ukraine, in Belarus or in Russia may result in lifting of radionuclides deposited on vegetation and organic layers. This is also the case in regions in which nuclear weapons tests were conducted during the Cold War.

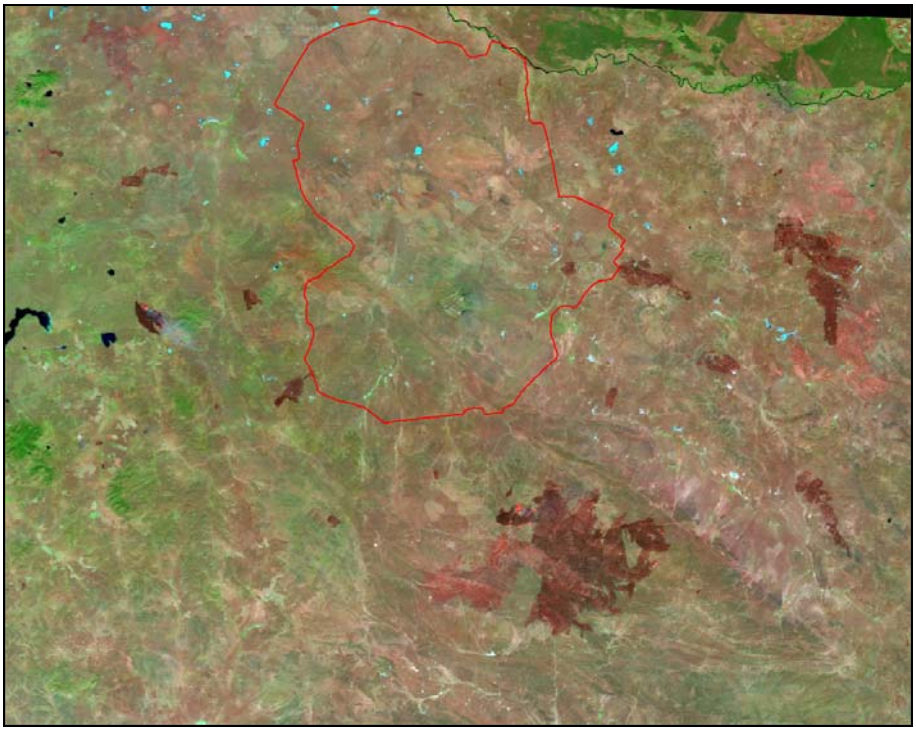


Figure 1. Aerial view of the Semipalatinsk Nuclear Weapons Test Site, Kazakhstan, with burn scars in the surrounding fallout regions. Date: 17 September 2007. Source: National Space Agency, Republic of Kazakhstan.

Unexploded ordnance, remnants of World Wars I and II, are found on several hundred thousands hectares of forests and other lands throughout Western, Eastern and Southeastern Europe. In Southeast Europe, notably in the countries of former Yugoslavia, active land mines are limiting access and management of large forest areas. In Bosnia and Herzegovina alone more than 200 000 ha of forests are

contaminated by land mines. Land mines are also found in the Southern Caucasus. The former combat grounds in and around Nagorno-Karabakh represent one of the major Unexploded Ordnance (UXO) polluted terrains worldwide. During the armed conflicts in 2008, e.g. Georgia and in the border region between Afghanistan and Pakistan, forest fires occurred as a consequence of military conflicts.

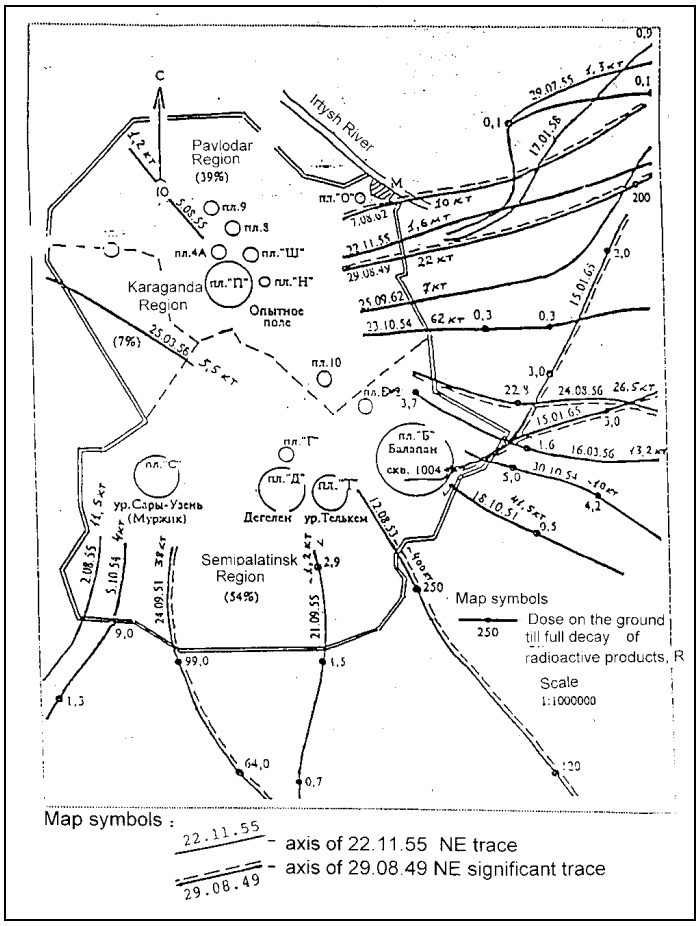


Figure 2. Map of Semipalatinsk test site and axes of most significant dose generating local traces of radioactive contamination. Source: Project # 245 "Radleg"

Besides radioactive pollution and explosives there are other threats caused by wildfires, e.g. the lifting and redistribution of mercury deposited in organic terrain. Air pollution generated by vegetation fire smoke is a major threat to human health and security.

This first seminar of its kind worldwide will give emphasis on the East Europe / Southeast Europe and the Caucasus region. However, contributions from North America and other parts of the world, e.g. on the inter-continental transport of hazardous fire emissions, will provided evidence that the issues addressed by the Seminar have a transboundary nature and a truly global significance.

The outcomes of this seminar will contribute to a better understanding of the problems of wildfires burning on contaminated terrain and their threats to human health and security.

The conveners of the seminar are indebted to the Council of Europe, Secretariat of the Euro-Mediterranean Major Hazards Agreement, the Organization for Security and Co-operation in Europe (OSCE) and the Environment and Security Initiative (ENVSEC) for providing funding for preparing and logistically supporting the seminar, as well as travel costs for participation of delegates from the Caucasus region. The conveners are also grateful for that the National University of Life and Environmental Sciences of Ukraine and the Ministry of Ukraine of Emergencies and Affairs of Population Protection from the Consequences of Chernobyl Catastrophe are hosting this seminar. The support by Yale University, Global Institute for Sustainable Forestry, and the Chopivsky Family Foundation, both U.S.A., are an

essential part of the cooperative work between the Ukraine and the U.S.A. in developing international cooperative efforts to address the problem of fires burning in the radioactively contaminated forests in the Chornobyl Exclusion Zone.

Figures 3 and 4. Land mines (upper photograph) in the Balkans and Unexploded Ordnance (UXO) (lower photograph) in the Southern Caucasus region: An immediate threat to human security in case of a wildfire. Source: GFMC

Welcome Address

Victor Poyarkov
European Centre of Technogenic Safety (TESEC)
EUR-OPA Major Hazards Agreement, Council of Europe

Nuclear power and radiological risk are our reality that is why the Council of Europe, Secretariat of the Euro-Mediterranean Major Hazards Agreement EUR-OPA (Open Partial Agreement), which I am pleased to represent at this seminar, supports the study of the Chernobyl experience so as to learn lessons that will permit us to provide better protection of people against technological and natural disasters.

The Chernobyl Exclusion zone is indeed a very contaminated area. After the Chernobyl accident in 1986, some forest died due to high radiation exposure and became the so-called “Red Forest”. In order to prevent wildfire in the forest leads to radioactivity release, that Red Forest was felled and buried in the same location of Exclusion Zone. Now, twenty three years after the accident, a new contaminated forest has grown in the same place and could be hazardous in the case of wildfire. We are thankful to the organizers of this meeting for having gathered high level experts on wildfire in the seminar and we hope it can lead to know more on the risks from wildfire at the Chernobyl Exclusion Zone so we may use the Chernobyl experience to promote better safety for all.

Just a few words about the Agreement. The EUR-OPA Major Hazards Agreement is a platform for co-operation in the field of major natural and technological disasters between Europe and the South of the Mediterranean. Its field of competence covers the major natural and technological disasters - knowledge, prevention, risk management, post-crisis analysis and rehabilitation.

The main objectives of the EUR-OPA Major Hazards Agreement are to reinforce and to promote co-operation between Member States in a multi-disciplinary context to ensure better prevention, protection against risks and better preparation in the event of major natural or technological disasters.

Wildfires are becoming an important risk in many areas of Europe in the last years. You all have in mind the forest fires in Athens this summer, and those of Portugal, Spain, the Balkans and again Greece in 2007 and 2008. It seems that climate change is also responsible for the increase in risk. In Chernobyl we combine both risks from fire and those from radiation. We are indeed hopeful that the EUR-OPA Agreement will continue to work in both the risks from radiation and wildland fires in the next years and improve resilience of communities to those hazards.

International Cooperative Efforts to Address the Problem of Fires Burning in the Radioactively Contaminated Forests in the Chornobyl Exclusion Zone

Chadwick D. Oliver
Global Institute of Sustainable Forestry
School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut, U.S.A.

An important impact of the accident at the Chornobyl Nuclear Power Plant in 1986 was to cover 260 000 ha of forest and former agriculture lands with radioactive strontium, cesium, europium, plutonium, and americium. The area was cordoned off as the “Chornobyl Exclusion Zone” (CEZ) but otherwise only lightly managed. Since then, research has obtained much information on the behavior and effects of the radiation on the forests, as well as the effects of light fires on the radiation and on people. The radioactive material moves throughout the trees and soil, with relatively little leaching to the ground water as long as the living plants and soil structure are present to recycle the materials. There is some health danger to forest workers from inhaling the dust; any harvested timber needs to be utilized with precautions, and collection of mushrooms and other edible plants are considered dangerous. Since the accident, relatively little attention has been paid to the forests. The fire detection and fighting equipment is quite old, access roads have not been well maintained, and the forests have become very crowded and infested with bark beetles – and thus more susceptible to wildfires.

Some small fires have occurred within the area; and a serious concern is the probability of a catastrophic wildfire such as those that have occurred in the western United States. Such large fires can very rapidly burn (and volatilize elements in) much of the organic matter, create their own weather pattern, and move

radioactive smoke for hundreds of miles in whatever direction the wind may blow. Once begun, these fires are almost impossible to control except by a change to favorable weather.

Unless managed, forests in the CEZ are naturally susceptible to wildfires because of the species, soils, and weather patterns. Analyses involving computer simulation show that the forests have become even more susceptible to wildfires because of their crowded condition – similar to the forests in the western United States. The analyses further show that proper tending that reduces the crowding dramatically reduces both the fire susceptibility and the intensity of any fire that does start. The lower intensity means that the fires could be readily controlled. The tending could be done with equipment that does not jeopardize the health and safety of the forest workers.

Three coordinated systems are proposed to reduce the catastrophic wildfire danger: a fire monitoring system, a fire fighting system including open access roads, and a system to thin and otherwise manage the forests. An estimated annual cost of US$ 20 million is needed to make the forests safe from catastrophic wildfires. These costs include modern monitoring sensors, modern firefighting equipment, activities to make the forest more accessible, and machines to thin the forest to reduce the fire susceptibility and intensity.

It was later realized that the actual health impacts of a catastrophic fire had not been analyzed. A new analysis was then done to assess the effects of radiation from a catastrophic wildfire in the CEZ. Preliminary results of this analysis will be presented later in this conference by Dr. Aaron Hohl. As he will show, preliminary results suggest that a catastrophic radioactive wildfire will not cause cataclysmic results. It does assume that plant crops directly exposed to the radioactive smoke would not be consumed, among other things.

The analyses will be further checked and then sent to respected scientists throughout the world for peer review. Our intent is that both the analysis and the peer reviews will be published for public dissemination.

An analysis of the public reaction in terms of panic and stress from the radioactive smoke; economic loss from destroyed crops and tainted reputation of Ukraine's agriculture products; economic loss from reluctance to invest in Kiev; social loss from people in Ukraine being considered genetically compromised; and the cumulative stress of this radiation and other stresses were not analyzed. Additionally, an economic analysis was not done to determine the cost/benefit of active management to avoid the catastrophic forest fires.

The analyses and airing of the radioactive fire issue was initiated by an "ad hoc" group of scientists, including Rector Dmytro Melnychuk and Dr. Sergiy Zibtsev of National University of Life and Environmental Sciences of Ukraine (NULESU), myself from the Yale University, and Dr. Johann Georg Goldammer of the Global Fire Monitoring Center (GFMC), Freiburg University / United Nations University. We took the initiative because no one else recognized the catastrophic wildfire potential of the forests. Other scientists from around the world freely joined the effort, giving constructive advice and time for the analyses. Throughout the process, our goal has been to bring attention to responsible administrative officials so the issue could addressed. To that end, we held conferences in 26-27 July 2007 and 6 October 2008 and held other individual meetings with other leaders and administrators. At total of 17 different countries, international governments, and NGOs were contacted. Early in the process, it was decided that the concern should not be made public because of the concern for arson and other terrorism.

The first lesson learned is that the scientific and technical capacity and cooperation exists to analyze and solve the issue in a cooperative manner. The initial scientists were joined by many volunteers who together and simultaneously analyzed the effects and tried to turn the issue over to the various international bodies, NGOs, and national governments. In all there was technical cooperation from over six countries and many institutions. The international group of scientists and other technical people had little direct obligation and authority. Many scientists were not funded. A private foundation, the Chopivsky Family Foundation, funded much of the science and meetings, with the NULESU, the Ukraine government, and Yale University funding other parts. The specialists worked in several languages and shared ideas and information constructively across three continents and two languages. When, in the middle of the issue, we realized that another analysis – the effect of the radioactive smoke on human health – was needed, there was no hesitation to do this even though it might alter our previous position.

On the other hand, the administrative capacity to address such an international issue is sadly lacking. Even before further analyses showed the danger was less dramatic than originally thought, the many countries, NGOs, and international governments acknowledged the danger but generally avoided

becoming involved – despite many efforts in group and private meetings. Now, two years since the first meeting the forest is still untended; and this conference is being held to obtain administrative accountability by someone before the fire does occur.

There is a need for these bodies to accept responsibility and at least inform the people of the level of danger. And, the “precautionary principle” and the “compassion principle” call for something to be done. The current lack of accountability – especially at the international and NGO level – can undermine the public respect for efforts to deal with other global hazards before they become disasters.

Figure 1. A 50-year-old Scotch pine plantation five miles from the Chernobyl nuclear power plant. The stand has been devastated by insects and is now at an extremely high risk for fire.

Figure 2. The crowded pine stands on sandy soils in the Chornobyl Exclusion Zone make the area highly susceptible to a catastrophic wildfire.

Figure 3. Thinning crowded stands makes them much less susceptible to a catastrophic wildfire (Photo from Yakama Indian Reservation, Washington, U.S.A.).

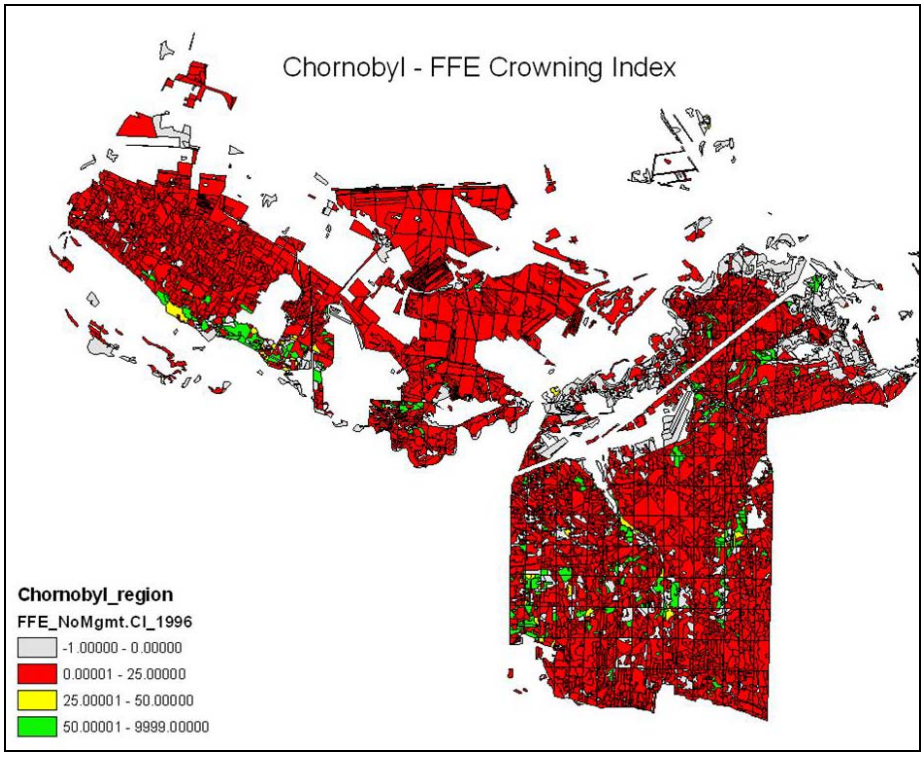


Figure 4. FFE Fire Risk Map using Crowning Index for 1996 with no management. Classes are High (0-25), Moderate (25-50) and Low (50+).

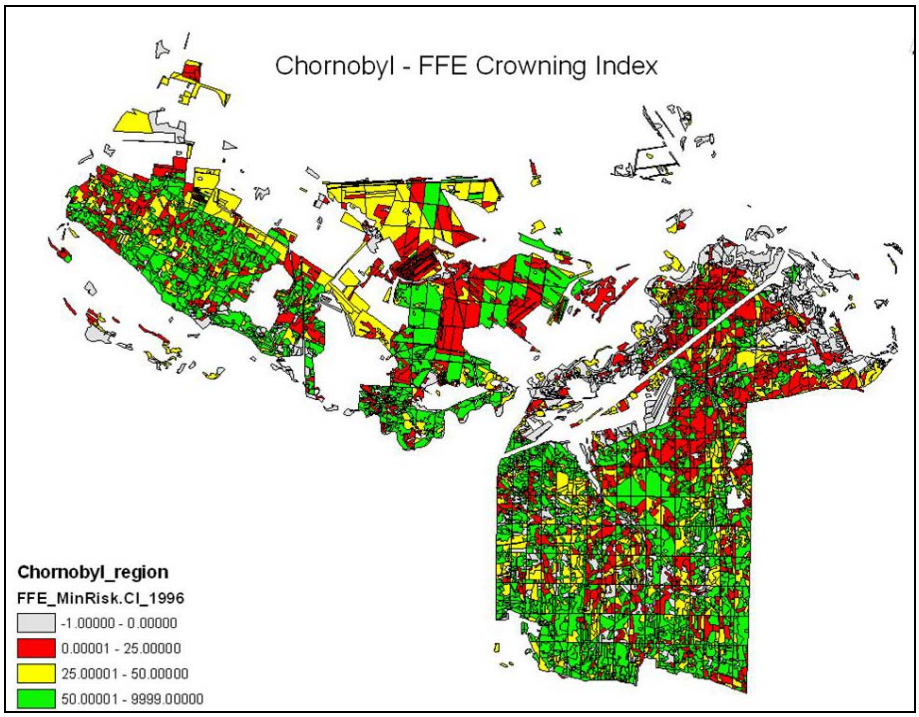


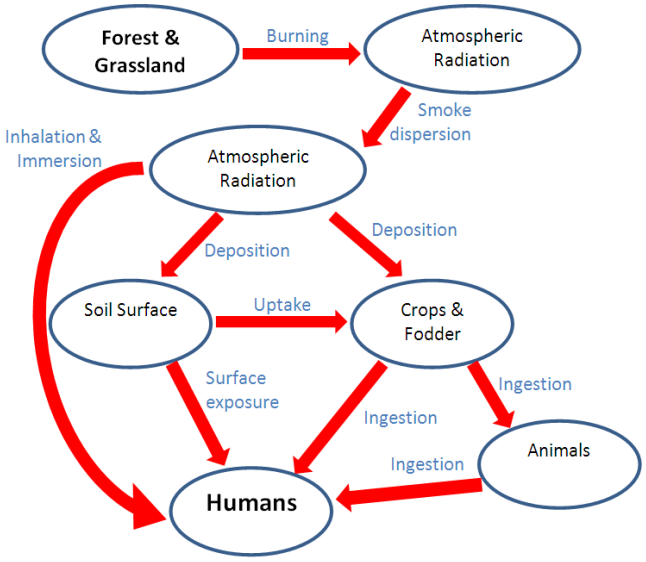
Figure 5. FFE Fire Risk Map using Crowning Index in 1996 with management to reduce fire risk.

Figure 6. Technical equipment such as this can enable the irradiated forests to be managed with minimal exposure of the workers to radiation (www.irmforestry.com).

Wildfire in the Chernobyl Exclusion Zone: A worst case scenario

Aaron Hohl and Andrew Niccolai
Humboldt State University and Yale University

A model to assess the potential implications of a catastrophic wildfire the Ukrainian portion of the Chernobyl Exclusion Zone (CEZ) on populations living and working near the CEZ was developed. The complete model consists of a source model, a transport model, and an exposure model. As a worst case scenario, it was assumed that a fire would consume the biomass of pine forests and former agricultural lands and release any associated radionuclides into the atmosphere. The transport model assumed that the wind would blow primarily towards Kiev throughout the fire event. The exposure model was used to estimate exposure through immersion and inhalation during the fire itself and ground exposure in the year following a catastrophic wildfire in the CEZ. The model was designed to be extremely conservative and most likely over-estimates potential exposure. The estimated exposure of populations 25 or more kilometers from the source of the fire through these three pathways is below the critical thresholds that would require evacuations. However, Ukrainian law would require limiting ingestion of certain foodstuffs to avoid exposure via ingestion.



Wildfire Hazard and Actions Needs for its Reduction on the Territories Contaminated with Radionuclides in the Chornobyl Exclusion Zone

Sergiy Zibtsev, National University of Life and Environmental Sciences
Richard Lasko, USDA Forest Service
Wei Min Hao, USDA Forest Service, Fire Sciences Laboratory
Diane Hutton, Fire Management Officer, Beaverhead-Deerlodge National Forest
Anton Kruchok, Administration of the Exclusion Zone

Problem of radioactive fires is exist on the forest area, that more than 0.8 million ha in the northern part of Ukrainian Polissia, where flammable Scotch pine forests were contaminated with radionuclides after disaster on Chornobyl Nuclear Power Plant in 1986. At the moment most part of that area is still contaminated, that limited forest and fire management activity and create a risk of occurring of large wildfires (Figure 1).

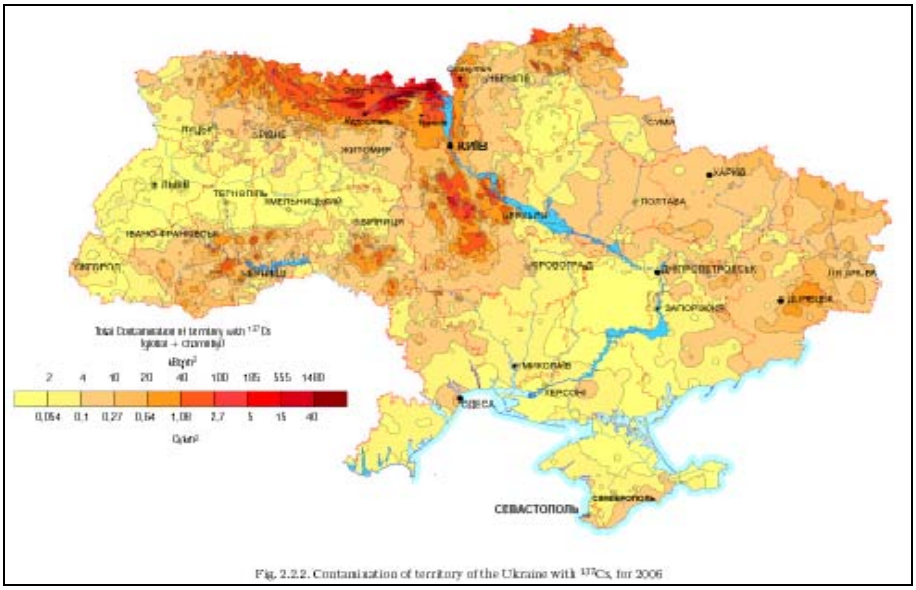


Fig. 2.2.2. Contamination of territory of the Ukraine with ^{137}Cs, for 2006

Figure 1. Contamination of territory of Ukraine with 137Cs in 2006. Source: National Report: "20 years after the Chornobyl disaster".

Most acute the problem is in the Chornobyl exclusion zone where high level of contamination synergized with absence or lack of forest and fire management. More than one hundred of small and medium wildfires caused by humans each year occurred in areas of formal agricultural land and settlement, but no large fire events happens since catastrophic fire in 1992 (Figure 2). In 1992 catastrophic fires affected a total area of 17 000 ha in the south part of the exclusion zone with relatively low level of level of radioactive contamination. Since that time large former forest area are still do not covered with forest because of slow processes of natural regeneration after fire dry forests sites (Figure 3).

Despite the relative successes in fire suppression, no active vegetation management is occurring to reduce the amount of fuel in the forests of the exclusion zone due to reduced budgets and the inability to utilize contaminated wood. Presently, the dense spacing of trees within the forests reduces the amount of understory vegetation with mostly dead needles covering the forest floor. This fuel structure causes fires to stay close to the ground with relatively short flame lengths and without the means of transitioning to large crown fires except under extreme weather conditions. However, as mature trees die and more sunlight reaches the forest floor, small young trees and some shade-tolerant trees will grow in these spaces. This forest succession process would result in more ladder fuels on the forest floor, thus increasing the risk of large crown (tops of trees) fires.

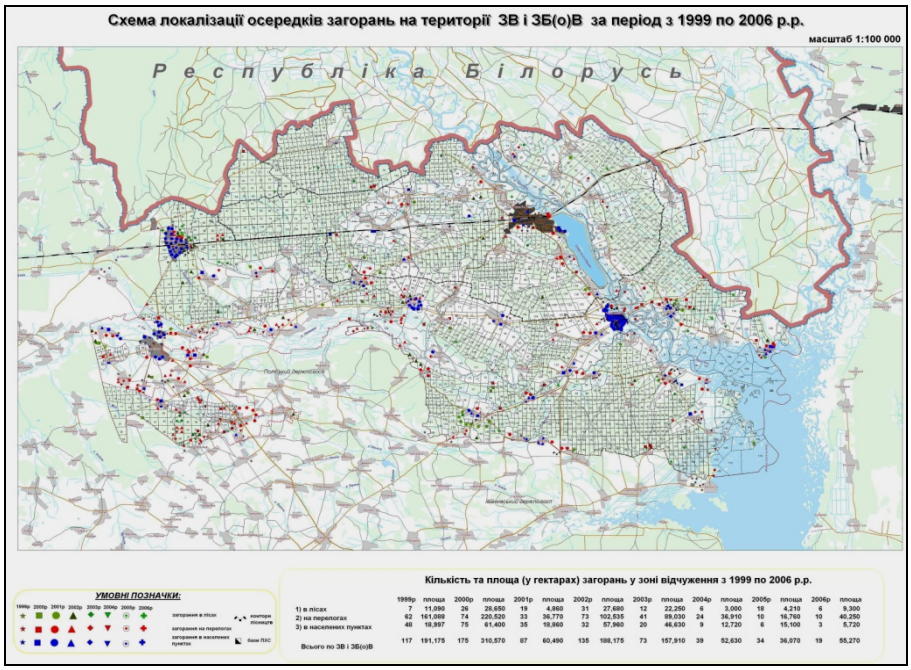


Figure 2. Map of the exclusion zone with locations of wildfires between 1999 and 2006. Source: Courtesy of the administration of the Exclusion Zone.

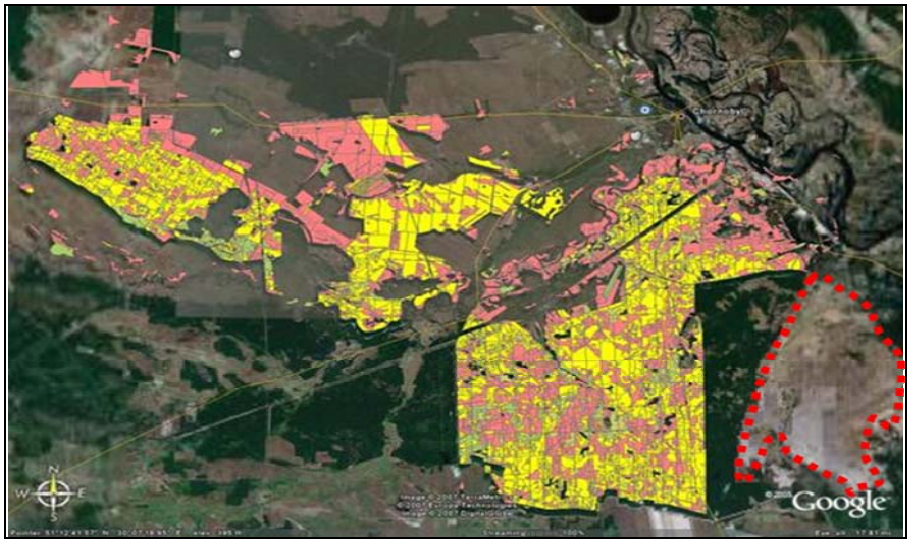


Figure 3. More than 5 000 ha of crown fire (red dots in left low corner) destroyed forests near village of Opachichi in the south part of the exclusion zone in 1992 that did not regenerate till now. Source: Google Earth image, courtesy of C. Oliver.

Because of limited forest management, Scotch pine stands are overstocked, stressed, and are susceptible to insects and diseases. For example, the gypsy moth (*Ocneria dispar)* has prospered in the exclusion zone causing 60-80% defoliation, root rot (*Fomitopsis annosa* Karst.) that has killed a large portion of trees, including a more than 1 300 ha near Leliv village (Figure 4).


Figures 4 and 5. Large areas of heavily contaminated and dry forests after insects outbreak near village of Leliv, 8 km South from Unit 4 of Chornobyl NPP, that poses high wildfire threat. Source: Courtesy of the administration of the Exclusion Zone.

In a framework of joint international project devoted to catastrophic fire risk reduction a number of recommendations were developed.

Strategic planning. A strategic plan identifying goals and implementation actions must be developed. This plan would build on previous planning efforts but would integrate those efforts into a cohesive strategy, integrating forest and fuels management with suppression and emergency management actions. The goal of planning should be to identify, prioritize, and integrate management actions to minimize the potential for wildfire growth, smoke production, while maintaining the capability of forests to stabilize nuclear contamination.

Assessment of fuels, fire behavior and radioecological conditions. Forest vegetation and fuel conditions must be assessed to determine the susceptibility of vegetation types to wildfire and fire spread and potential fire behavior characteristics. This assessment must be integrated with an assessment of radioecological conditions in order to determine where fire prone vegetation exists in relation to the highest levels of radionuclides.

Stratified sampling of the vegetation types should be sufficient to meet the fire potential assessment The FIREMON Fuel assessment techniques would provide an excellent way to capture the relevant vegetation and fuels information in an organized fashion. GIS capability is essential to development an assessment of conditions in the EZ. This system would allow managers to integrate fuels and radioecological inventory data in order to assess conditions and develop assist in developing management strategies.

Strategic placement of fuel breaks. Establishing fire barriers with less fire prone vegetation covered with deciduous forests consisted from *Quercus robur*, *Betula pendula, Populus tremula*, and *Alnus glutinosa* will help minimize the spread of wildfires in the zones of highest contamination is highly recommended. Conducting fire simulation and modeling will allow forest managers to develop projects that would strategically replace fire-prone *Pinus sylvestris* with hardwood species landscape and reduce the overall growth rate of a fire. Slower moving fires have reduced intensity and increase the chance that periods of moderate weather or suppression action can reduce fire size and subsequently limit smoke production. This information would form the basis for prioritization of potential fuels reduction and vegetation management activities and reduce the acres requiring treatment.

The techniques to accomplish fuels modification and vegetation conversion projects will require further analysis. High capacity chipping machines would be a potential method to reduce fuels to manageable volumes for long term disposal or internment. These machines would to be modified to protect workers exposure to radionuclides. Long term disposal and storage strategies must also be developed.

Suppression and emergency management capability. A robust and efficient suppression capability must be maintained to meet the objective of minimizing the size of wildfires in the exclusion zone. This force must be capable of quickly detecting and extinguishing wildfires. The wildfire suppression organization must be capable of integrating out of area resources to assist in effectively responding to simultaneous

occurrences of wildfire under periods of high fire potential. Suppression actions must also be conducted so as to minimize the effects of radiation on suppression forces. The following actions should be undertaken to achieve the suppression objective:

- Implement a system of fire detection and meteorological monitoring sites to provide continuous detection and meteorological monitoring;
- Secure dependable helicopter capability to enable rapid, surveillance, assessment and suppression capability;
- Enhance initial attack capability by obtaining water bucket capability for the helicopter. Effective use of a helicopter with water dropping capability allows quicker response, limits fire spread, ultimately resulting in less exposure of firefighting crews to radionuclides;
- Establish protocols for firefighter safety in radioactive contaminated environments. Monitor and enforce the use of these protocols by firefighting resources;
- Adopt an Incident Command System (similar to the U.S. approach) and train personnel in its use. This will allow the effective and rapid integration of non exclusion zone personnel into management of overload fire situations in the exclusion zone.

Translation of relevant methodologies. Training and reference material on fuels management, fire behavior assessment, wildfire suppression and the incident command system should be translated into Ukrainian. These materials would serve as useful reference in the development of Ukrainian strategies, implementation plans, and firefighting protocols to successfully manage the wildfire situation not only in the EZ but also the rest of the country. It is recommended that the following publications and references be translated into Ukrainian: Fireline Handbook, Incident Command System references and training materials, FIREMON reference publications.

Communication and Information Technologies
New tools for Wildfire Management

Jean-Michel Dumaz
Centre de Secours Principal d'Aix en Provence, Aix en Provence, France

This presentation will address the lessons learned from wildfires burning in Southern France and the methods and results of firefighting preparedness and operations. These lessons are the keys of success to reduce area burned and for managing large fire disasters.

Communication and information technology tools for an operational decision making system are presented and include the following elements us at the Service Départemental d'Incendie et de Secours des Bouches-du-Rhône (SDIS13):

- Detect, localize, alert and organize the response
- Automatic detection system
- Localization of the fires
- Fire propagation modeling
- Dispatch of firefighters
- Monitoring and management of the operations
- Live (real-time) observation
- Team positioning
- 3D mapping

The automated rapid fire detection and monitoring system "Fire Watch" is a candidate for the use in contaminated terrains in order to reduce the risks of contamination or explosions to ground staff.

Figure 1. Automated rapid fire detection control panel of the “Fire Watch” system at SDIS13

The use of Prescribed Fire on Nature Conservation Areas in Germany Contaminated by Unexploded Ordnance (UXO)

Johann G. Goldammer
Global Fire Monitoring Center (GFMC)

In large parts of Eurasia the use of fire and other disturbances have contributed to shape landscape patterns of high ecological and cultural diversity and value, e.g. heathlands, open grasslands, meadows, and swidden (shifting) agriculture sites, as well as open and stress-resilient forest ecosystems. The rapid socio-economic changes in the past four decades and the recently increasing trend of rural exodus all over Eurasia, however, have resulted in abandonment of traditional land-use. With loss of intensive land cultivation, including traditional burning practices, large areas of Europe are now converting to fallow lands, a process that is associated with ecological succession towards brush cover and forest, and an overall loss of open habitats. Besides the loss of valuable biodiversity the abandoned lands are subjected to an increase of wildfire hazard – a trend that is revealed by a growing number of extremely severe fire disasters. The fires burning in Greece in 2009 and 2009 are an expression of this trend.

In order to maintain the openness and biodiversity of these high-value conservation areas, as well as the reduction of fuel loads – and thus the threats of wildfires of high severities – the use of controlled fire (prescribed fire) is increasingly promoted in temperate-boreal Europe.

In Germany many of the high-value nature conservation sites are located on former military training areas or shooting ranges. Some of these areas have been used by the military since more than 100 years, others were newly created and especially used during the Cold War. Many of these military exercise areas were located on the territory of the former German Democratic Republic, used by the Soviet Army and the Warsaw Pact allies. The disturbances caused by military activities (e.g., mechanical impacts of direct shooting, fires started by shooting, mechanical impacts by tanks and other vehicles) have resulted in the creation and maintenance of valuable open ecosystems. With the closing of the exercise areas many vegetation types, notably the *Calluna vulgaris* heathlands, are becoming subjected to succession and development towards forests – a trend that is rather undesirable from the point of view of landscape and biodiversity conservation.

On these former military sites there are some obstacles for using prescribed fire as they are densely contaminated with Unexploded Ordnance (UXO), which may explode during prescribed burning operations and also during wildfires.

UXO are also abundant on the former battlegrounds of Word War II around Berlin, especially inside forests. While these forest sites are not necessarily candidates for the use of prescribed fire, they are constituting a major threat to humans. Wildfires burning in the forests around Berlin, Brandenburg and Saxony States have often resulted in heavy explosions and casualties.

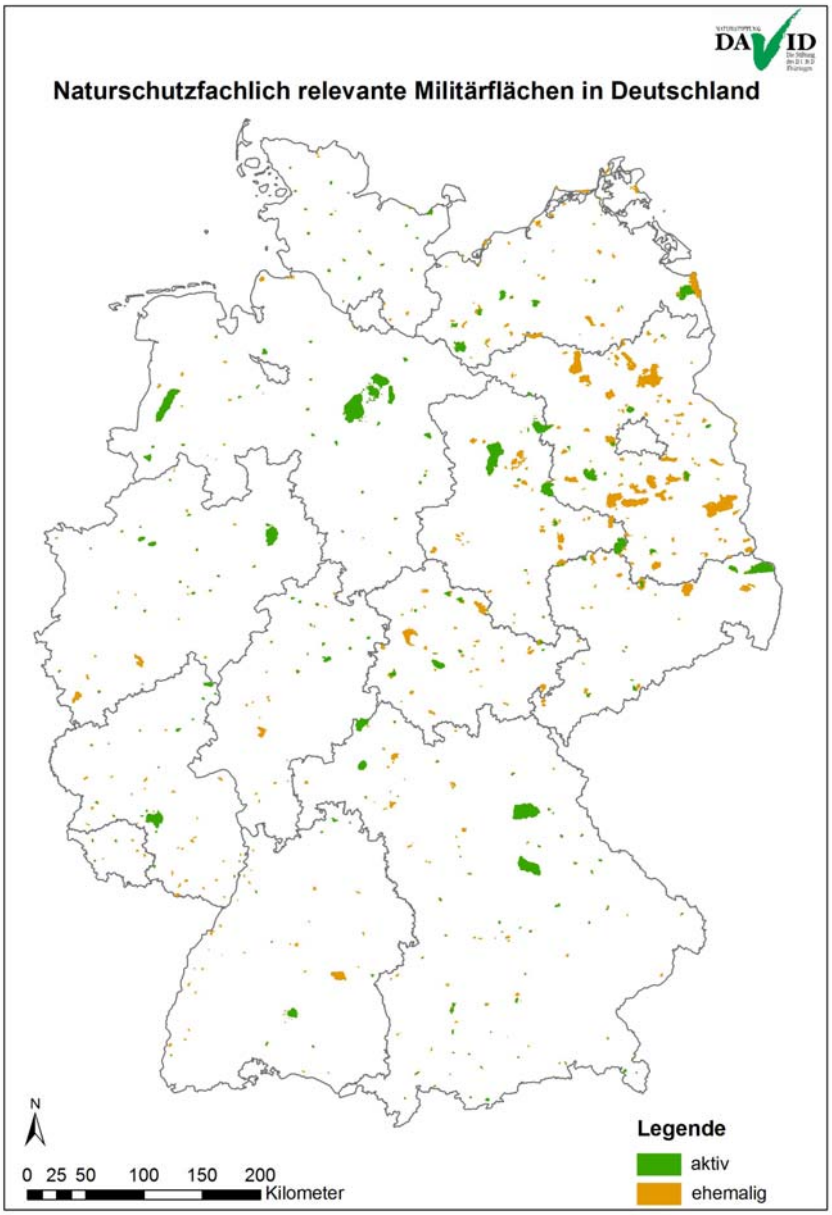


Figure 1. Extent of UXO-contaminated sites in Germany on active and abandoned military training and shooting ranges that have high conservation values cover ca. 250 000 ha. The concentration is high on the territories of Eastern Germany – especially on former Soviet training sites. Problems: Contamination with toxic and hazardous waste on sandy soils with high flammability. Source: Nature Foundation *Naturstiftung David* (Germany).

A new approach is presented on the use of prescribed fire to maintain openness of UXO-contaminated terrain. In 2009 a project in Brandenburg State has been launched in the nature conservation site „Heidehof-Golmberg“ in Teltow-Fläming County, South of Berlin. This site is classified according to the “Fauna-Flora-Habitat Directive“ (FFH) of the European Commission and belong to an overall area of ca. 70 000 ha of FFH lands in Brandenburg State that are endangered by succession and loss of open habitats.

Figure 2. The „Heidehof-Golmberg" conservation site requires the application of prescribed fire on ca. 1800 ha over the coming years. For the first time the project aims to use fire for halting succession and for regeneration of vegetation and at the same time facilitating UXO clearance. With the removal of dead and live vegetation layers the UXO becomes visible on the soil surface and can be cleared easier.

Mine Action Organization – The Croatian Experience

Oto Jungwirth
Director of Croatian Mine Action Centre; Assembly President, Cluster for Humanitarian Demining, Croatia

The presentation will demonstrate the organization of the mine action system in the Republic of Croatia, system development and achievements reached using the newest technologies and methodologies. Since more than 50% of the mine contaminated areas in the Republic of Croatia cover forest terrains, the presentation will focus on the experience in defining mine suspected area in forest terrains, as well as on demining activities in such areas. Besides, the paper will also present the capability of the Republic of Croatia in solving landmine problems in other countries.

Wildfire Management and UXO, Land Mines and Radioactivity in the Region of Southeast Europe/Caucasus

Nikola Nikolov
Faculty of Forestry-Skopje, Republic of Macedonia

During the meetings of the UNISDR Southeast Europe/Caucasus Wildland Fire Network (Ohrid-2005, Sofija-2007 and Skopje-2008) the problem with wildfires management and terrains contaminated by Unexploded Ordnance (UXO), land mines and radioactivity was recognized. Also, this problem was recognized during two missions: OSCE-led Environmental Assessment Mission to fire affected territories in and around the Nagorno-Karabakh region (September 2006) and the Ecological Damage Assessment of the Wildfires in the Former Yugoslav Republic of Macedonia in 2007, Joint Mission by the UNEP-OCHA Joint Environment Unit, UNEP, UNDP and GFMC (August 2007).

The most affected countries in the region are: Bosnia and Herzegovina, Croatia, Serbia, Macedonia, Georgia, Ukraine, and Armenia. The origin of the UXO, land mines and radioactivity is different from country to country.

The origin of the land mines and UXO in Bosnia and Herzegovina, Croatia and Serbia is from the civil war from the last decade of 20th century. It is estimated that about 300 000 ha are contaminated by land mines and UXO (mostly along to the line of conflict during the civil war). This is a significant problem and challenge for forest fire management.

In the Republic of Macedonia the threat of UXO to be triggered and exploded by forest fire is stemming from World War I. Most contaminated is the former line of contact of 1917 (LoC between the Austro-Hungarian, German, Bulgarian and Turkish forces in the North and the Entente in the South), where large numbers of grenades and mines are threatening fire-fighters and civilians.

The problem with land mines is very significant in the Southern Caucasus region.

One of the biggest problems in Ukraine is wildfire risk situation in the forest still contaminated by radioactive fallout from the 1986 Chernobyl nuclear disaster. The ecological, social, and economic consequences of potential catastrophic radioactive wildfires are terrifying.

The UNISDR regional Southeast Europe / Caucasus Wildland Fire Network is giving priority to address the problems associated with fires burning on contaminated terrain. This seminar is an important step towards raising awareness of problems that are largely ignored by politics and policies.

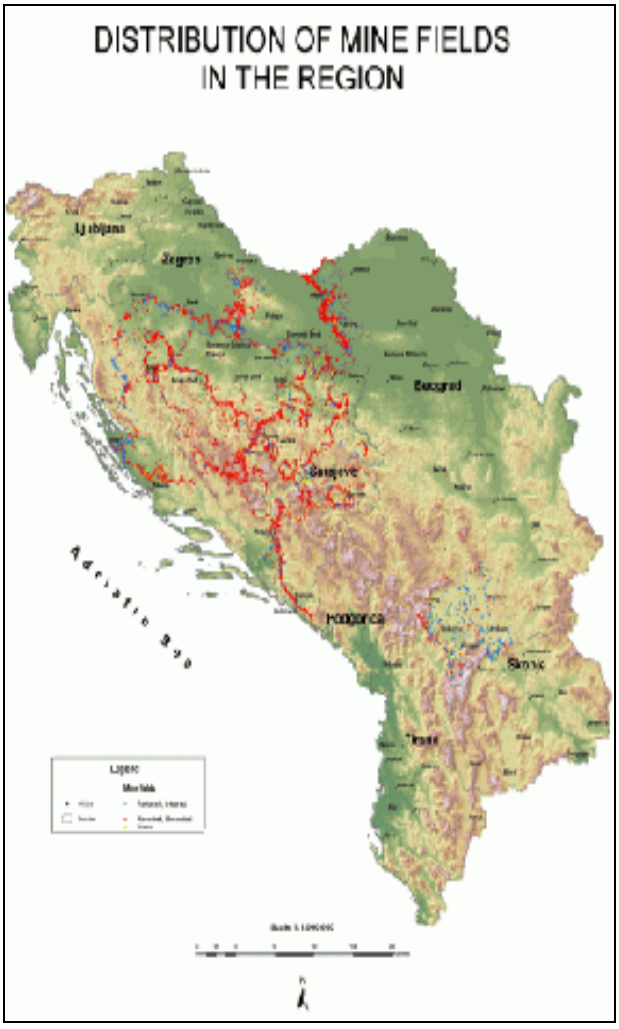


Figure 1. Mine fields in the region of Bosnia and Herzegovina, Croatia and Serbia

Figure 2. Unexploded ordnance from World War I (Republic of Macedonia, 2007)

Fire Management in Areas Contaminated by Land Mines in Turkey

Ertugrul Bilgili
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It is reported that Turkey has a total of 982 777 land mines, of which 818 220 are anti-personnel, and 164 497 anti-tank mines. Mined areas are frequent along the borders with almost all neighboring countries. Turkey first started mining its borders using anti-personal mines at the southern border after 1950s and mostly between 1954 and 1959 to control illegal trespasses and smuggling across the borders. It is also reported that some areas were also mined between 1989 and 1992 for only security reasons in the fight against terrorism. Reports indicate that there have been at least 257 explosions with either injuries or death. A total of 53 people were killed and 204 wounded as a result of the mine explosions in these areas.

Figures 1 and 2. Land mine warning sign and clearing operation in Turkey.

Turkey signed the Ottawa Agreement on the abolition of the use, storage, manufacturing and the distribution of Anti-Personnel mines and on their stockpile destruction in 2003 and acceded to the treaty in 2004. According to this agreement, Turkey has committed itself to and assumed the responsibility of destroying the anti-personnel land mines it has in its stocks and clearing mined areas by 2014.

Mined areas cover not only the borderline but also potential agricultural areas and forests. Only at the border between Syria and Sanliurfa, a province in the Southeastern Turkey, there is about 14 000 ha of productive agricultural land area lying mined as a strip along the border. Forested areas are shrubs composed mostly of oaks. Although forest fires in these regions are of little concern in terms of ecological damage and public safety, depending on time and place, areas with land mines poses a great danger in fire suppression. Thus, forest fires in these areas can not be controlled effectively. Fire management in these areas are limited to the fire suppression in mine-free areas. Transboundary fire escapes also create problems. Fire control and cooperation of countries become extremely difficult especially when there are no mechanisms or agreements in place for cooperation between countries.

Demining Works Complete in Kvemo Khviti

Ilia Edilashvili
Emergency Management Department, Ministry of Internal Affairs, Georgia

One year after the war of 2008 in Georgia the village of Kvemo Khviti in Gori District has been completely cleaned up of mines and unexploded materials. The international organization “Norwegian People’s Aid” has carried out the clearance works in the village. All the unexploded military materials have been swept from the territory and the demining lands were turned over to the local governments. Kvemo Khviti is one of the three completely cleaned territories.

According to the statement of Mr. Kartlos Koranashvili, Deputy Head of Administration of MoD - “About 500 000 square meters were cleaned up from the debris of war.

Mine-diffusion specialists discovered the unexploded 57 cluster bombs and 33 unexploded ammunitions in the village. There is a point on 90 safe lives.” Along with the international organizations, specifically prepared 39 locals were also participating in the cleaning of the dangerous territory in Gori district.

By request of the Ministry of Defense of Georgia and its coordination the international organization “Norwegian People’s Aid” has been working in cooperation with the US-British organization HALO TRUST to clear unexploded ordnance since September 2008. In the framework of the memorandums of understanding “On Humanitarian Mine Action Assistance” signed between the Defense Ministry of Georgia and above mentioned organizations, they perform mine and highly explosive materials clearance procedures those parts of Georgian territory which were bombarded and mined in August 2008.

The humanitarian mine cleaning process on hazardous territories in Gori, Kareli, Khashuri and Kaspi regions will complete towards the end of October current year.

Unexploded Ordnance and Land Mines on the Territory of Armenia and Overview on Fire Management in Armenia

Nver Gevorgyan
Ministry of Defense of Armenia

and

Arthur Voskanyan
Ministry of Emergency Situations of Armenia

The presentation provides a comprehensive overview about unexploded ordnance and land mines on the territory of Armenia. Special attention will be paid on forested areas and the work of the Armenian Demining Center. Afterwards Mr. Arthur Voskanyan, Ministry of Emergency Situations will provide an overview about wild fire and fire management in Armenia.

Figure 1. Roadside fire burning near Yerevan, October 2006. Photo: OSCE / GFMC Mission, 2006.

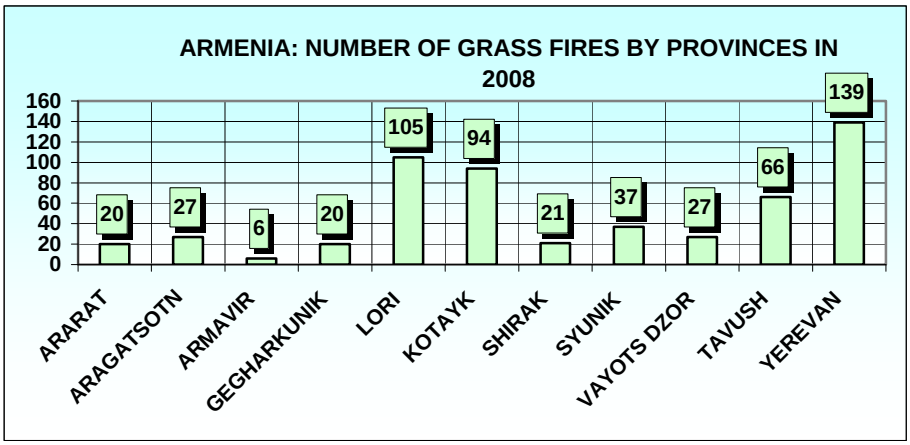


Figure 2. Detailed grassland and forest fire statistics were presented in the paper by A. Voskanyan.

Aerial Fire Management on Terrain Contaminated by Radioactivity

Andrey M. Eritsov
Aerial Forest Fire Center of Russia "Avialesookhrana"
Pushkino, Moscow Region, Russian Federation

and

Johann G. Goldammer
Global Fire Monitoring Center (GFMC)

Many countries of the world including the Russian Federation nowadays prioritize the development of advanced technologies for wildfire management on terrain contaminated by radioactivity, unexploded ordnance and land mines. The Aerial Forest Fire Center of Russia (Avialesookhrana) jointly with partners for many years is developing modern aerial fire fighting technologies for this purpose. With participation of Avialesookhrana the Water Dropping System VSU-5A from Helicopter with the foam injecting system as well as air tanker technologies were developed and widely used. Concepts for the use of unmanned aerial vehicles (UAV) for fire danger monitoring and fire management, which provide real-time information for safe and rapid fire fighting operations are currently developed. The monitoring system based on satellite remote sensing, which has been developed by the Aerial Forest Fire Center, is also available for monitoring radioactively contaminated territories. However, its efficiency depends on cloudiness, satellite overpasses and size of fires.

The use of UAV is very actual especially since territories contaminated by radionuclides are usually far away from the airports and operations of heavy aircraft are expensive and limited. UAV may take off from small spots. In the past UAV have been used for many years for military purposes only, but in the last few years first successful experiments and operational flights for fire monitoring have been conducted in some countries, e.g. in the USA and Canada. In the Russian Federation there are many companies that are developing fixed-wing and helicopter UAV technologies. The Aerial Forest Fire Center of Russia has started first tests in 2006 in Vladimir Region using the *Eleron* UAV produced by the Eniks, Ltd. in Kazan. The weight of the UAV is just 3 kg and may fly on the altitude up to 3 km with a cruising speed of 100 km/h. *Eleron* is equipped with video and still photo cameras. Based on the successful results of the tests Avialesookhrana acquired two Unmanned Aerial Systems (UAS) *Eleron* in 2007. Every UAS consists of two airplanes.

During the 2007-2008 fire seasons the systems were used for fire monitoring in Moscow region, Tomskaya and Rostovskay oblasts. During this period aircrafts made 75 flight hours, detected more than 10 fires in every region. In Tomsk region the UAS were widely used by fire brigades in operations on large fires in extended territories to monitor fire fronts and perimeters for safe operations since the deployment of aircraft was limited. The experience of using this technology provided Valuable insight to use it not only in fire management. For example, the Federal Forest Agency of Russia has ordered Avialesookhrana to test the use of UAV / UAS for other monitoring tasks in the forestry sector, e.g. illegal logging, pest and disease control, and in forest inventory.



Figures 1-3. Development and use of unmanned aerial systems and aerial firefighting technologies in the Russian Federation are suitable for detecting, monitoring and fighting wildfires in contaminated terrains.

Under that order in August / September 2009 Avialesookhrana conducted field tests in the Noginsk peat land areas of Moscow region inviting UAV / UAS producers from different regions. ZALA company from Irkutsk, ENIKS from Kazan and ZALA ltd from Izhevsk showed demonstrated the technologies that these companies have developed. Based on the results of this experiment Federal Forest Agency will recommend to the regions of Russia, which are responsible for all activities in forest sector including fire management, to acquire recommended UAV / UAS.

Radioecological Consequences of Fires Affecting Forest Contaminated by Radionuclides

A.N. Razdaivodin, E.A. Zhukoff and A.I. Radin
All-Russian Research Institute of Silviculture and Mechanization of Forestry, Russia

As a result of failure on the Chernobyl atomic power station, the forests of the Southwest of Bryansk region (Russia), near the border with Belarus and Ukraine, have much extremely polluted by cesium-137 (^{137}Cs) – 40-180 Ci km^{-2} (with gamma radiation dose rate o 0.60-7.00 mkSv h^{-1}) on a territory about 250 km^2 with its position practically in the geographical center of Europe.

In 2008-2009 the All-Russian Research Institute of Silviculture and Mechanization of Forestry (VNIILM) carried out researches according to radioecological danger of forest sites in the territory of Bryansk region, including the forest sites effected by forest fires in different years. Research realized on 35 testing areas, on where size and weight of forest litters, the presence in them ^{137}Cs (activity (A) of ^{137}Cs, Bq/kg) was estimated depending on ecological conditions, landscape, silvicultural conditions, forest types and density of radioactive pollution of the ground by ^{137}Cs (Ci/km^2).

It is established, that levels of contamination of forest litter substances (presence of activity the ^{137}Cs) in the given territories have averaged from 20 up to 60 kBq kg^{-1}. Today's, ashes and forest litter (burn up), what were formed on the forest sites effected by forest fires, have a level of the activity of ^{137}Cs maintenance from 40 up to 100 kBq kg^{-1}, that at 4-10 time exceeds a level established for low-active radioactive waste products.

The basic stock ^{137}Cs in forest ecosystems (40-60 % now days) contains in a forest litter which in coniferous forest has average weight from 40 up to 80 t/ha. It is established, that in case of presence the density of radioactive contamination levels ^{137}Cs from 5 up to 40 Ci km^{-2}, total (sum) activity ^{137}Cs in a forest litter in the given forest sites has range about 0.2-1.2*10^6 kBq ha^{-1}. It was recognized, that sum activity the ^{137}Cs on a forest sites depend from the activity (A^{137}Cs) in forest litter substance (Bq/kg), size of the forest litter layer (cm) and its load (weight in t/ha).

Potentially fire-dangerous and the most radioactive-dangerous natural ecosystems (with the most essential negative radioecological consequences after effecting by fires) us are considered the secondary young-aged coniferous and mixed forests with prevalence of the coniferous species, what presented on the hardly radionuclide polluted territories about 30% of the total area.

Wildfires and the Global-Scale Cesium-137 Background Activity

Gerhard Wotawa[1], A. Becker [2], R. D'Amours[3], L.E. De Geer [4],
M. Jean [3], R. Servranckx [3] and K. Ungar[5]

[1] Central Institute for Meteorology and Geodynamics, Austrian National Data Centre for CTBT Verification, Vienna, Austria
[2] Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, Provisional Technical Secretariat
[3] Environment Canada, Meteorological Service of Canada
[4] Swedish National Defense Research Agency
[5] Health Canada, Radiation Protection Bureau

For the verification of the Comprehensive Nuclear-Test Ban Treaty (CTBT), a global high-precision radionuclide monitoring network is being established. With respect to key nuclides like Cesium-137 (^{137}Cs), the network is about one order of magnitude more sensitive in terms of minimum detectable activity concentrations (MDC) compared with typical national networks. Some of these stations are being

built in very remote locations, which is an ideal prerequisite to study non-natural background radiation levels. In 2003, a CTBT monitoring site in Yellowknife, Canada was put in operations. This station, from the very beginning, showed a continuous low-level summertime ^{137}Cs background which could not be immediately explained. For all CTBT radionuclide stations, daily operational computations of Source-Receptor Sensitivity (SRS) fields are done by means of atmospheric transport modeling. The SRS fields for Yellowknife were folded with a ^{137}Cs emission inventory that was constructed using monthly 1°MODIS/TERRA fire pixel counts and subsequently used to predict monthly average ^{137}Cs concentrations at the station (see Figure 1).

By comparing model predictions with the monitoring results, we showed that the inter-annual variability of the ^{137}Cs background observed in Yellowknife can be fully explained by transport from fires burning in the boreal forests of North America and Asia (see Figure 2). Also the levels detected were well in line with historical deposition estimates from past human activity. This finding has important implications. First, it demonstrates that ^{137}Cs deposited world-wide from past nuclear testing and from accidents is re-injected into the atmosphere by combustion to a significant extent and on a large scale. Second, these results show that the material is subsequently transported across great distances.

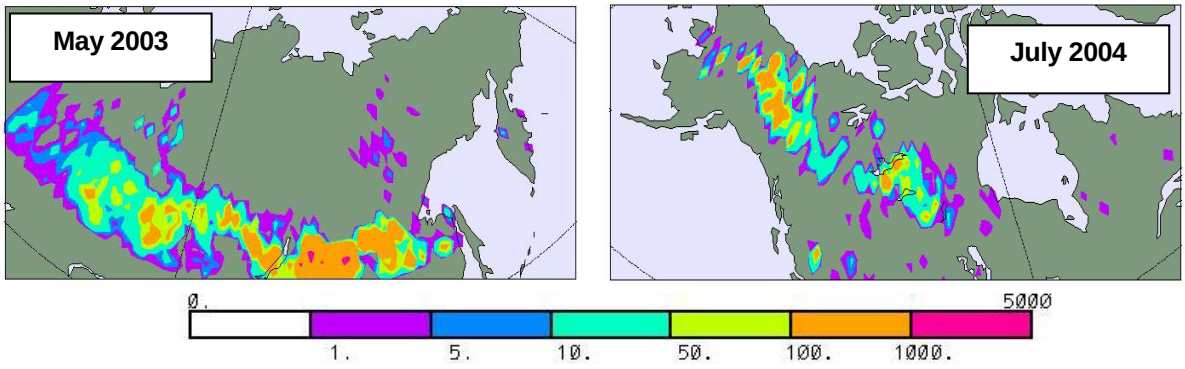


Figure 1: Monthly fire pixel count product based on data from the MODIS instrument onboard of the Earth Observation System (EOS) Satellite "Terra" for Siberia in May 2003 (left) and North America in July 2004 (right).

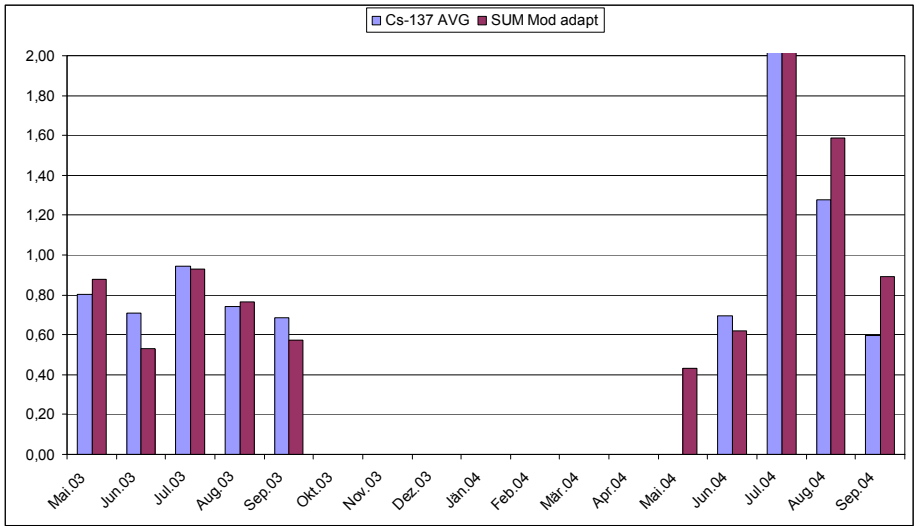
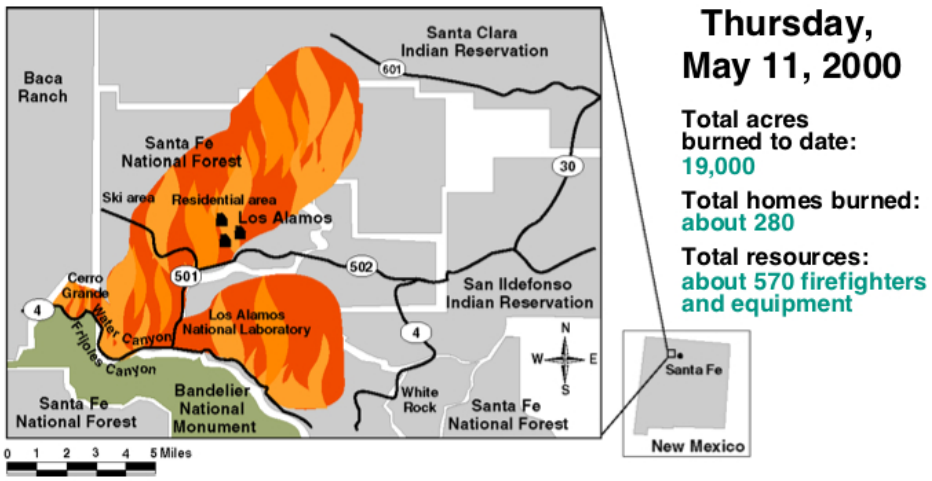


Figure 2: Comparison of computed versus observed Cesium-137 concentrations in Yellowknife in 2003 and 2004. Above-MDC activity was only observed in summertime.

Asymmetric Wildfire in the United States

Richard Lasko
Assistant Director, Fire and Aviation Management, US Forest Service, Washington D.C., U.S.A.

The traditional challenges of managing wildland fires in the United States and globally continue to provide the focus for analysis and programmatic development. While this focus is logical and warranted, attention needs to be placed on emerging or currently unrecognized threats to firefighters and the public from wildland fires operating in atypical environments. The United States Forest Service is currently identifying and investigating potential situations that may confront our firefighters and citizens.



Past events, such as the Cerro Grande Fire in 2000, where firefighters were confronted with wildland fires in and adjacent to radioactive material, provide some indication of the nature and potential of wildfires operating in unconventional situations. Problems of conducting firefighting operations in hazardous chemical deposition zones and areas of unexploded ordinance are also examined in this paper. Examples of existing protocols for engaging wildland fires in these environments are provided along with suggestions for improvements in managing wildland fires in uncharacteristic environments.

Wildland Fire Smoke Pollution: Khabarovsk Case Study

Leonid Kondrashov
Pacific Forest Forum, Russia

Forest fires are one of the principal factors changing forest ecological systems. The greatest number of inflammations occurs in the places of people concentrations and intensive territory development. However, in Khabarovsk Territory the major forest area burns in the remote regions where the use intensity is not very high but it is more difficult to bring there firemen and fire equipment.

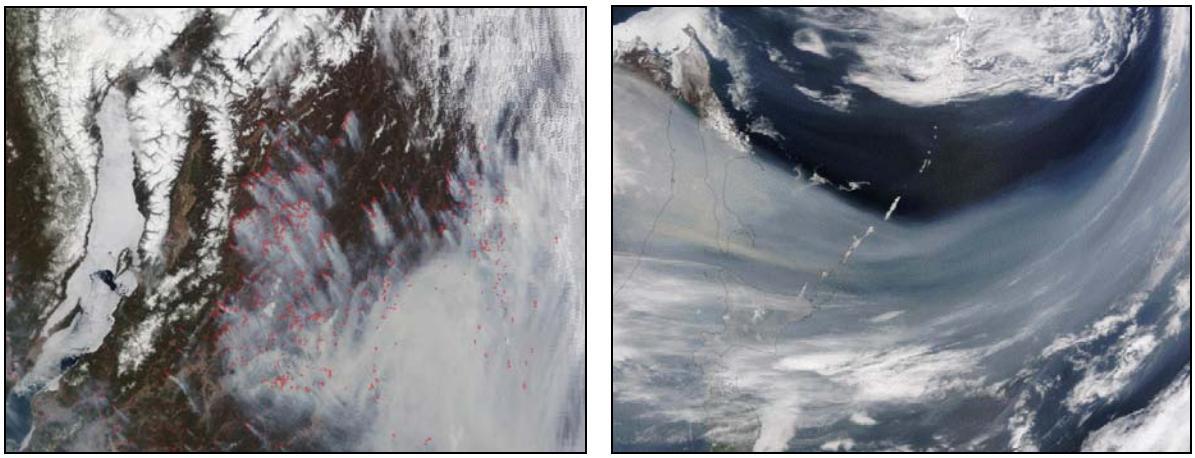
The average rate of forest coverage of the Far East of Russia is 55%. The forest area is 275.1 million ha with total wood stock 20 billion m^3 including 10 billion m^3 of coniferous. The distribution of forest lands in the region is uneven – from 1.6 million ha in Jewish autonomous region to 143.1 million ha in Yakutia and by the stock – from 82 million m^3 in Chukotka to 9 billion m^3 in Yakutia.

Khabarovsk Territory, is the most burning region in Russia. The frequent recurrence of extreme dry seasons, abundance of combustible materials representing high fire danger, mountain relief, inaccessibility of territory, and the hard wind regime predetermine the high probability of forest fire occurrence, the speed of its spread, and also the difficulties to control it. In addition, the level of financing and material support of forest fire services has sharply decreased during the last decade. This has negatively influenced the efficiency of the firefighting work to prevent, detect and to put out forest fires in time.

Khabarovsk city is a capital of Far East Federal District and located on the bank of the Amur river amongst wide taiga resources. The population of Khabarovsk about 600 000 people strongly suffers from the annual vegetation fires caused by both natural and anthropogenic factors. At the weekends and holidays the quantity of ignitions in forests reaches 40 percent of their number during the week (100 percent). Up to 93 percent of all ignitions arise in ten kilometer zone around populated localities and in three kilometer stripe along the roads, mostly visited by population. So called agricultural burnings annually circle the city by a smoke curtain when the owners of country houses are trying to get rid of unneeded vegetation and raising the atmosphere pollution. At those days the levels of carbon monoxide for a long period exceeded the maximum allowed concentration by 3.13 times and in some cases – by 24 times.

Figure 1. Fire smoke pollution in Khabarovsk in 2008

According to estimations, the stock of dry fuels in the forests nearby Khabarovsk is approximately 1 to 25-30 kg m^{-2}. Forest fires consume nearly all forest litter composed of fine vegetation, emitting all litter contaminants into the atmosphere.



Figures 2 and 3. Long-range transport of smoke is demonstrated by these two satellite images recorded by the Moderate-Resolution Imaging Spectroradiometer (MODIS). Left: Fire activities on 8 May 2003 at 0400 UTC (11:00 local time) Southeast of Baikal Lake. Right: Smoke column stretching from fires in the Transbaikal Region to Sakhalin, Japan, and Alaska (8 May 2003).

Fires have several different effects on the health and well-being of the population of Khabarovsk. Inhalation, ingestion, and dermal absorption are the routes of exposure to smoke pollutants. Inhalation is the most common pathway through which humans absorb constituents of biomass smoke. Dermal absorption might also occur through a person's surface cells. Gastrointestinal absorption is another pathway of exposure to the pollutants emitted by forest fires. Medically significant biophysical effects of biomass smoke include acute, subchronic, and chronic effects on public health. The spectrum of adverse physiological effects ranges from temporary, relatively minor eye, nose, and throat irritations, to persistent cardiopulmonary conditions, and less-commonly, to premature death. Vegetation fire smoke is the source of several other types of adverse health impacts. The direct diffusion of biomass smoke into surface water is a source of nitrogen in water sources. Similarly, excess phosphorous partly results from the leaching of ashes that drop and dissolve directly in stream water. Mercury, a toxic metal that is a powerful neurotoxin is sometimes present in forest fire smoke and may be deposited in water supplies. In some situations, the exposure of surface waters to sunlight may decrease, such as when biomass smoke and haze block ultraviolet light (UV-B). The risk to human health occurs when a reduction in UV-B is sufficient enough to increase the growth of bacteria and pathogens in water supplies.

Exposure to forest fire smoke can impact psychosocial wellbeing since sometimes the smoke events last in Khabarovsk for weeks and months. Interruptions in social services (transportation disorders) and damage to infrastructure cause individual and group stress.

Vegetation Fire Smoke and Human Health Impacts

Milt Statheropoulos[1,2], Sofia Karma[1], and Johann G. Goldammer[3]

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[2] European Center for Forest Fires, Council of Europe (ECFF)
[3] Global Fire Monitoring Center (GFMC), Max Planck Institute for Chemistry c/o Freiburg University / United Nations University, Freiburg, Germany

Smoke produced from wildfires is generally considered a complex mixture of gases, liquids and solids that can have significant contribution to air pollution and visibility impairment. However, among the most serious effects of the smoke produced seems to be the possible health impacts on the exposed population and the fire-fighters; exposure to Vegetation Fire Smoke (VFS) can result to acute, short and long-term health effects that can be correlated to the toxicity of the smoke components, the frequency, the duration and the intensity of the exposure, as well as the sensitivity of the receptors. VFS can also exist as a more complicated mixture depending on the flame-front pathway. This is especially true in case that the vegetation fire is in the interface of an urban or industrial area. In addition, consequences are undefined in case that the fire expands to a radio-contaminated area; the transboundary transport of the generated smoke plume can contribute to a significant increase of the number of people affected. Exposure and vulnerability of humans to fire emissions is an issue to be addressed for limiting smoke impacts on human health and security.

Appendix 1

Yale University
School of Forestry and Environmental Studies and Global Institute of Sustainable Forestry

Statement of the International Meeting

"Reducing Risk of Disaster from Catastrophic Wildfires in the Chornobyl Irradiated Forests"

Kiev, Ukraine, 27 July 2007

The international meeting on "Reducing Risk of Disaster from Catastrophic Wildfires in the Chornobyl Irradiated Forests" was held in the National Agricultural University, Kiev, Ukraine, 26-27 July 2007. The meeting was organized by Yale University School of Forestry and Environmental Studies Global Institute of Sustainable Forestry and by the National Agricultural University of Ukraine. The meeting was sponsored by the Chopivsky Family Foundation and held under the auspices of the United Nations International Strategy for Disaster Reduction (UNISDR), Global Fire Monitoring Center (GFMC), and the Government of Ukraine, with participation of the Council of Europe (CoE), the Organization for Security and Cooperation in Europe (OSCE), the World Conservation Union (IUCN), the Ministry of Ukraine of Emergencies and Chornobyl Affairs, and the State Forestry Committee of Ukraine. The meeting brought together more then 80 participants from Belgium, Belarus, France, Germany, Spain, Switzerland, Russia, Ukraine, and USA, representing government and international organizations.

Participants at the meeting were presented with a comprehensive picture of the current wildfire risk situation in the forest still contaminated by radioactive fallout from the 1986 Chornobyl nuclear disaster. Concerns include fire risk assessment ability, potential effectiveness of the currently existing forest fire suppression system, potential of proactive forest thinning to reduce fuel hazard, fire detection ability, and the amount of technical and human resources allocated to fire management. The ecological, social, and economic consequences of potential catastrophic radioactive wildfires were discussed. The critical components of the problem were specified and fire risk forecasts were demonstrated.

A strategic plan for disaster risk reduction with preliminary cost estimates was presented, entitled "First Draft of Proposed Implementation Plan and Budget for Reducing the Risk to Kiev and other Areas of Forest Fires with Radioactive Smoke from Forests impacted by the 1986 Chornobyl Nuclear Disaster." It is being revised and edited.

Recognizing the high regional and international risks of catastrophic wildfires in the Chornobyl irradiated forests and the potential negative consequences for the environment and population, the participants of the meeting declared the following:

1. A high wildfire hazard has emerged on the area of 260 000 hectares of forests and former agricultural lands of the Exclusion Zone around Chornobyl Nuclear Power Plant. The forests and former agriculture lands are highly contaminated with long-resident radionuclides of the ^{238}Pu, $^{239+240}$Pu, ^{137}Cs and ^{90}Sr. The greatest wildfire hazard is found in dying Scotch pine forests on a total area of up to 5 000 ha according to some estimations. Despite a general prohibition of access to the Exclusion Zone, human-caused ignition is common in the area. During long drought periods and extreme wind conditions there is a risk that large, high-intensity crown fires will occur that will lift radionuclides to the atmosphere with the smoke, resulting in uncontrolled radioactive fallout downwind.

2. There are insufficient levels of technical and human resources in proactive wildfire risk reduction and in fire suppression in the Exclusion Zone. Poorly maintained forest roads and water sources and the lack of an early warning and detection system do not allow rapid response and transportation of fire equipment and personnel to the fire. Consequently, the fires will probably not be suppressed at an early stage before they become catastrophic.

3. The radioactive wildfire hazard can be dramatically reduced with proactive management and reactive fire suppression. However, these activities require a continued investment of much more money than is currently being allocated to these efforts.

4. It is highly probable that fallout of significant amounts of radionuclides, carried by wind in wildfire smoke up to hundreds and thousands of kilometres downwind, will affect human populations and result in secondary contamination of lands, according to the current state of scientific knowledge in modelling resuspension and redistribution of radionuclides during wildfires. As a consequence of radioactive smoke inhalation, fire fighters and staff working in the Exclusion Zone and nearby as well as distant populations, even in other countries, are particularly threatened. At present there is no effective regional and national plan of response and risk management in case of a radioactive wildfire disaster.

5. The investment climate and international image of Kiev, the Kiev region, and elsewhere that the radioactive smoke may travel will be negatively affected by a catastrophic, radioactive wildfire in the vicinity of the Exclusion Zone – or even by high awareness of the potential for such a damaging wildfire. The cost of lost investment will probably be much greater than the cost of dramatically reducing the wildfire risk by appropriate investments in proactive forest management and a sufficient fire suppression program.

Taking into consideration risks and relevance of the issues described, the participants of the meeting agreed in defining the need of urgent, coordinated and collective actions for solving the most critical problems related to the radioactive fire problem. In particular, the participants recommended the following:

1. Joint Ukraine and international financing on an ongoing basis must be found to initiate an international project: “Reducing Risk of Disaster from Catastrophic Wildfires in the Chornobyl Irradiated Forests” that would include all components needed to address the problem.
2. Details of the project objectives and operations as well as the critical/priority areas need to be targeted and possible scenarios need to be elaborated. A project office, led by Yale University School of Forestry and Environmental Studies Global Institute of Sustainable Forestry and by National Agricultural University of Ukraine should be established.
3. A multi-stakeholder coordination council (committee) of the Project needs to be established, a leader / coordinator determined, and thematic sub-groups organized.
4. The National Agricultural University of Ukraine should initiate a pan-Ukrainian dialogue on a collaborative (inter-agency and multi-stakeholder) approach and provide coordination of the project towards addressing the issue of reducing the radioactive wildfire risk.
5. Neighbouring countries, notably Russia and Belarus, and other international stakeholders / organizations need to become involved in the process of preparation and implementation of the project.
6. Accurate, transparent information on the current radioactive wildfire risk, progress in implementing the risk reduction, results achieved, and status of the project need to be provided to society and stakeholders on an ongoing basis through mass media and seminars about implementation of the project and results achieved.

To international organisations, central and local authorities:

1. Transboundary / international cooperation in capacity building for proactive forest management and fuel mitigation is needed (e.g., through bilateral or multilateral agreements) as well as reactive fire suppression preparedness and response to address the transboundary risks of radioactive fire emissions.

2. Yale University School of Forestry and Environmental Studies Global Institute of Sustainable Forestry and National Agricultural University of Ukraine as coordinators of the project should actively cooperate with international organizations, notably ENVSEC (UNEP / OSCE / UNDP /

NATO), UNISDR / Global Wildland Fire Network / Wildland Fire Advisory Group, CoE / EUR-OPA, and IUCN during project implementation.

3. Ukraine may consider developing a memorandum of understanding in Cooperation with CoE / EUR-OPA with the aim of attracting more attention and commitment at government levels.
4. Ukraine may consider approaching FAO for cooperation towards utilizing the TCP tool for medium-sized and rapidly implementable project elements.

5. The current radioactive wildfire risk problem and progress toward risk reduction should be presented at the CoE-led conference on "Learning from Chornobyl legacy to make European energy safer: Role of local communities, authorities and central governments in emergency preparedness and management" to be held in Ukraine in September 2008.

6. A remote system for early fire detection should be implemented covering the whole area of the exclusion zone, which will be based on smoke and visual detection; to establish an improved communication system, installing a satellite receiving station for wildfire monitoring should be considered.

7. Advanced fire management training should be conducted for fire services, forestry services and others involved, preferably at the regional level (e.g., in the Chornobyl Zone, jointly for Ukraine, Belarus, Russia, in cooperation with the Global Fire Monitoring Center and the focal Fire Coordination Centre in Ukraine [NAUU]).

8. Terminology should be standardized for protocols and commands of response for radioactive fire management and suppression of fires. The possibility should be investigated of implementing the "Incident Command System" (ICS) under the UN auspices in accordance with the recommendation of 4th International Wildland Fire Conference, Seville, Spain, 2007.

9. Representatives of civil society, notably local communities, should be included in disaster prevention, preparedness and mitigation.

To Yale University School of Forestry and Environmental Studies Global Institute of Sustainable Forestry, Institute of Forestry and Park Management NAUU, Research Institute of agricultural radiology NAUU, All Ukrainian Research Institute of Civil Protection of Population and Territories from Emergencies, other research organisations

1. Scientific assessments should be provided of all risks which potentially can arise during wildfires as a basis for the development of a fire management strategy.

2. A GIS-based decision-support/expert system should be developed that will integrate air quality radiation monitoring systems, spatial peculiarities of contamination, forest inventory data, fire models and fuel accumulation, and other needed data to obtain a clear, quantitative picture of the area of project implementation.

3. Fire danger assessments of forest and non-forest lands and their classifications and models of fire behaviour should be developed; and radionuclide resuspension and migration should be analyzed relative to fuel loading, contamination level, and weather conditions.

4. The CoE and Yale University School of Forestry and Environmental Studies Global Institute of Sustainable Forestry should organize an exchange, with the assistance of Global Fire Monitoring Center, between Ukraine, USA and EU for training in innovative and economically feasible methods of forest management, wildfire risk reduction, fire management, and planning.

State Department - The Administration of the Exclusion Zone and Zone of Unconditional Resettlement of the Ministry of Ukraine of Emergencies and Chornobyl Affairs, State Special Enterprise "Chornobyl Forest"

1. The draft paper described herein should be reviewed, improved, specified, and integrated into the project for implementation. The draft paper is entitled: "First Draft of Proposed Implementation Plan and Budget for Reducing the Risk to Kiev and other Areas of Forest Fires with Radioactive Smoke from Forests impacted by the 1986 Chornobyl Nuclear Disaster"

The implementation will include proactive and preventive measures, including:

a. Designing and implementing forest management, fire management and nature conservation plans / strategies;
b. Completing a fuel inventory (inventory of combustible matter inside forests) and forest inventory on the areas with high fire risk and building digital maps;
c. Enhancing the fire management infrastructure and safety, including improving placement of strategic fire breaks and other elements of fire management based on risk assessments and upgrading or replacing existing but outdated fire fighting equipment such as radio communication, fire trucks, and water pumps; (Most of the equipment dates back to the 1970's and would not be effective in suppressing any catastrophic fires in the region.)
d. Implementing thinning (removal of some trees in crowded forests) with use of advanced technologies such as "cut-to-length" machine systems with cutting shears, so that the operator sits in a controlled-air cab and is not exposed directly to the radioactive dust. These machine systems should be tested and modified to ensure worker safety in the irradiated forests;
e. Organizing forest fire monitoring.

2. Strategies and measures should be developed to manage the impacts of radioactive smoke on human health and security both inside and outside of the Exclusion Zone.

3. Endorsement / application of the "Fire Management Voluntary Guidelines" (UN / FAO / UNISDR) should be considered.

The meeting participants thanked the organizers, sponsors and host of the conference for bringing together the international community concerned with the problem of radioactive wildfires. The participants welcomed the offer of organizers and sponsors to hold a second conference, tentatively in 2008, for monitoring the progress toward implementation of this report and for continuing the discussion and strategy development for mitigating radioactive catastrophic fires.

Co-chair of the organisational committee of the Conference,
Rector of the National Agricultural University of Ukraine,
Academician of the National Academy of Science of Ukraine — Dmytro Melnychuk

Co-chair of organisational committee of the Conference,
Director of the Yale University School of Forestry and
Environmental Studies Global Institute of Sustainable Forestry, and
Pinchot Professor of Forestry and Environmental Studies — Chadwick Oliver

Co-chair of the organisational committee of the Conference,
Director of the Global Fire Monitoring Center (GFMC) — Johann G. Goldammer

Secretary,
Associate Professor of the Institute of Forestry and Landscape
Management of the National Agricultural University of Ukraine — Sergiy Zibtsev

Appendix 2

Ministry of Ukraine of Emergencies and Affairs of Population Protection from the Consequences of Chornobyl Catastrophe
National University of Life and Environmental Sciences of Ukraine
Yale University School of Forestry and Environmental Studies
Global Fire Monitoring Center
Chopivsky Family Foundation

Statement of the International Round Table on

„Reduce Risk of Disaster from Catastrophic Wildfires in the Chernobyl Irradiated Forests"

Ministry of Ukraine of Emergencies and Affairs of Population Protection from the Consequences of Chornobyl Catastrophe, Kyiv, Ukraine
6 October 2008

The International Inter-Agency Round Table „Reduce Risk of Disaster from Catastrophic Wildfires in the Chernobyl Irradiated Forests" took place on 6 October 2008 in the Ministry of Emergency of Ukraine and was the second event devoted to the issue after International Conference "Reducing Risk of Disaster from Catastrophic Wildfires in the Chornobyl Irradiated Forests", held at the National University of Life and Environmental Sciences of Ukraine (NUBiP of Ukraine) in July 2007.

Participants of the Round Table were administration of the Ministry of Emergency, Management of leading Ukrainian interested organizations and institutions (Ministry of Economy, Ministry of Agricultural Policy, State Forestry Committee, National Academy of Science of Ukraine, Ukrainian Agricultural Academy, Academy of Medical Science, NUBiP of Ukraine), international organizations (Global Fire Monitoring Center, Yale University School of Forestry and Environmental Studies, Chopivsky Family Foundation, US Embassy in Ukraine, NGOs, Swiss Co-operation office in Ukraine).

Participants of the Round Table were informed on steps made in Ukraine and abroad to settle the issue in the period of 2005-2008. The Conception of the National State Program on catastrophic wildfire risk reduction in the exclusion zone was presented and discussed.

Participants of the Round Table recommended:

1. To create within a month the Inter-Agency Working Group with participation of all stakeholders (ministries, institutions, research and educational institutions, international organizations) to work out a plan of impartial scientific analysis of risks and consequence of catastrophic wildfires, to define and coordinate all urgent actions for wildfire risk reduction and improvement of current systems of wildfire prevention.
To assign the Ministry of Emergency and NUBiP of Ukraine to serve as Project Coordination Team.

2. To commission an International / Inter-Agency Working Group:

a) To specify with assessment of finance the action plan (offered at the international conference at NUBiP of Ukraine in 2007) of technical and organizational measures on reducing risks of disaster from catastrophic wildfires in the Chornobyl irradiated forests and conception of State program of Chornobyl wildfires risk reduction, taking into consideration the positive experience of the current wildfire prevention system.

b) To consider expediency and necessity of elaborating a State program on the improvement of wildfire management in Ukraine, catastrophic wildfire prevention in hazardous wildfire zones like the Chornobyl irradiated forests, Autonomous Republic of Crimea, as well as the South and South-East regions of Ukraine.

c) To produce documents on Conception of the State program on wildfire emergency in the Chernobyl irradiated forests with the State financing for 2010-2012 for the Cabinet of Ministers of Ukraine to consider and approve.

d) To make a decision about the way and the content of appeal to international organizations on behalf of the Ukrainian government (World Bank, The European Bank of Reconstruction and Development, UN FAO) to set up an international project comprising technical and financial support for applying up-to-date international skills and equipments to cope with wildfires in irradiated forest zones, to train staff, etc.

3. To refer to Swiss Co-operation office in Ukraine to provide a grant for preparation and carrying out fire prevention informational campaign among local population and village communities, located on contaminated territories around the Chornobyl Exclusion zone, as local population is considered to be mainly responsible for wildfire ignition in the areas.

4. To express appreciation to the founder of the International Chopivsky Family Foundation for active participation in settling the issues of Chornobyl exclusion zone and for financing the activities taken. Also to extend thanks to Professor Chadwick Oliver from the Yale University School of Forestry and Environmentally Studies, to Professor Dr. Johann G. Goldammer, the head of Global Fire Monitoring Center for their active involvement to resolve the issue.

Chairman of the Round Table Deputy Minister of Ukraine of the Ministry of Ukraine of Emergencies and Affairs of Population Protection from the Consequences of Chornobyl Catastrophe	Volodymyr Kholosha
Vice Chairman of the Round Table Rector of National University of Life and Environmental Sciences of Ukraine, Academician	Dmytro Melnychuk
Vice Chairman of the Round Table Director of the Global Institute of Sustainable Forestry of Faculty of Forestry and Environmental Studies at Yale University, Professor	Chadwick Oliver
Vice Chairman of the Round Table Director of the Global Fire Monitoring Center (GFMC), Max Planck Institute for Chemistry, c/ Freiburg University and United Nations University (UNU), Professor	Johann G. Goldammer
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