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THE SECOND ROUND TABLE:

"ECOLOGICAL IMPACT OF FIRE. DEFORESTATION AND FOREST DEGRADATION. RECLAMATION OF DEVASTATED LANDSCAPES"

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THE SECOND ROUND TABLE PROGRAM:

Kuzyk A.D. (Vice-rector for research and science, Lviv State University of Life Safety, Doctor of Agricultural Science, Professor) – Forest Fires Science Research;

Chalyy D.O. (Vice-rector of education, Lviv State University of Life Safety, PhD (in Engineering), docent), **Kobylkin D.S**. (Associate professor of the department of fire-fighting tactics and emergency and rescue operations, Lviv State University of Life Safety, PhD (in Engineering)) – Improvement the operational actions of fire and rescue departments during putting out wildfire;

Gulida E. M. (Head of Department of Fire-Fighting Tactics and Emergency and Rescue Operations, Lviv State University of Life Safety, Doctor Honoris Causa, Doctor of Sciences, professor) – Localization of forest fires;

Karabchuk D.Yu.(consultant on sustainable development, PhD (in Agriculture)) - The role of the public in development of the forestry policy of Ukraine. Experience of "Lisova Varta" during 2017-2018;

Lazarenko O.V. (Associate professor of the department of fire-fighting tactics and emergency and rescue operations, Lviv State University of Life Safety, PhD (in Engineering), Assistant Professor) – Logistical and technical aspects of ensuring the fires suppression in ecosystem;

Tovarianskyi V. I. (Lecturer of the department of operation of vehicles and fire and rescue equipment, Lviv State University of Life Safety, PhD (in Engineering)) – Modeling of pine stands fire at young ages;

Chernyavsky M.B. (Associate professor of the Department of ecology UNFU, PhD (in Agriculture), Assistant Professor) – Forest biodiversity and its conservation;

Shukel I. V. (Associate Professor of the Department of Landscape Architecture, Landscaping and Urban Ecology, UNFU, PhD (in Agriculture), Assistant Professor) – Reafforestation Processes After Fires;

Popovych V.V. (Chief of Environmental Safety Department, Lviv StateUniversity of Life Safety, Doctor of Technical Science, Assistant Professor) – Impact of landscapes fires on the physical and chemical characteristics of soil.

SPONTANEOUS COMBUSTION OF COAL MINE DUMPS IN THE NOVOVOLYNSK MINING INDUSTRIAL AREA

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One of the largest mining regions of the Lviv-Volyn coal basin, located on the border of Lviv and Volyn regions of Ukraine, is the Novovolynsk mining industrial region. Currently, there are 3 mines in the study area, where about 200 thousand tons of waste rocks are transported annually from them onto the ground surface, and 28 waste dumps have been formed from these rocks with an estimated mass of over 32 million tons. The mine dumps are formed by argillites, aleurolits, sandstones, coal slates, hard coal and pyrite. According to the mineralogical composition, the dump rocks include: argillite - 97% which contains 1-4% sulfur-containing mineral pyrite, aleurolit - 17-28%, sandstone - 2-20%, coal - 1-17%.This type of solid industrial waste, occupying large areas, is, in terms of ecology, an integral source of environmental impact, involving processes of self-ignition [5].

The cause of spontaneous combustion of coal-containing waste heaps is that coal absorbs molecular oxygen from the air on its surface; this oxygen forms a carbonaceous unstable peroxide compound that is easily decomposed while releasing active oxygen that oxidizes coal and converts it into oxygen-rich, stable compounds. Since this process is exothermic, it is accompanied by an increase in temperature, accelerating the oxidation process which ultimately leads to spontaneous combustion of the entire dump. In addition, long-term monitoring of the conditions of emergence of endogenous fires in the mine dumps of the Novovolynsk mining region makes it possible to identify a number of causes that lead to this phenomenon. Conventionally, they can be divided into natural and technological ones. Among the natural causes is the quality of coal itself in the dumps (in particular, its chemical activity - the ability to react with oxygen) and also geological factors. The main geological factors include: depth of coal occurrence, degree of coal metamorphism, its petrographic composition and recovery, ash content, moisture content, sulfur content, gas content [6].

When analyzing the essence of the process of spontaneous combustion of coal mine dumps, it should be said that spontaneous combustion is associated with the processes of weathering when hard rocky materials are destroyed and transformed into semi-bumpy and loose masses. Inside the dumps, favorable conditions are created for oxidation and subsequent burning, leading role in this belongs to the activities of microorganisms. The sulfur content in the dumps reaches 10% (sulfide sulfur - up to 84%), and its oxidation is carried out by thionbacteria (*Thiobacillus ferrooxidans).*They are usually autotrophic microorganisms that use CO_2 to build their bodies and receive energy when oxidizing sulfur and its reduced products [1,2].

Oxidation and combustion of dumps of mine rocks is accompanied by emissions of a wide spectrum of volatile components, the main of which is the water vapor formed during the evaporation of rain precipitation, as well as the release of bound water directly from minerals and rocks. Water is a mineral-forming medium for most of the newly formed minerals: sulfates, hydrocarbonates, carbonates, phosphates. It was found that during long-term self-heating of the dump waste, sulfate-acid zones are formed that contain bleached, amorphic mass and concentrated sulfate acid which smokes in the air. Due to the oxidation of the pyrite, which is present in the waste, and formation of sulfuric acid, the heavy metals pass into a mobile form, which increases the toxicity of the dump substrate and adversely affects the settling and development of plant organisms [3,4].

Thus, mine dump burning leads to significant changes in the composition of the atmospheric air and results in acid rains, polluting the soil and forming visible sulphated areas. For example, on average, 4-5 tons of carbon oxides and 600 to 1,100 kg of sulfur anhydrideas well as small amounts of hydrogen sulfide, nitrogen oxides and other combustion products are released from one burning dump per day. As a result, dumps of coal mines are subject to severe water erosion.

Conclusions. In general, characterizing the impact of waste heaps as a result of exogenous processes, we can distinguish a number of negative consequences for this territory:

- there is a change in the temperature regime of the air due to the release of thermal energy and the change in the physical composition of the atmospheric air as a result of entering dump dust;
- change in the chemical components of the atmosphere due to emission of toxic gases;
- infiltration of toxic compounds through a waste dump body into the soil, and lowering of demographic indexes and deterioration of human health;
- reduction in biodiversity and its productivity, as well as in environmental tolerance.

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IMPROVEMENT THE OPERATIONAL ACTIONS OF FIRE AND RESCUE DEPARTMENTSDURING PUTTING OUT WILDFIRES

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According to the data sets of fires registration that are taken from the local departments of the State Emergency Service of Ukraine (further – SES of Ukraine) during 2018, there were 78608 registered fires in Ukraine. During the analyzed period by the departments of SES of Ukraine 2,335 people were rescuedin the fires, including 350 children. In addition, 26,838 buildings and structures, 2,149 units of equipment, 633 tons of coarse forage and material assets over 6.2 billion UAH were saved during fires [2]. Also there were wildfires in the forests ruled by the State Forestry Agency. Wildfires damaged and destroyed thousands of forest hectares, that led to significant environmental and material damages and it required the involvement of a large number of fire-rescue means to bring them under control.

Wildfires are divided into grassland, ridge, spotted and underground. They are characterized by a class of fire hazard plantations, geographical location of forests,the beginning and the end of the fire hazard period, a class of fire hazard of meteorological conditions [3]. An important component in the process of putting out wildfire is the operation of aerial reconnaissance with the involvement of air components of SES of Ukraine. The head of forest fire suppression with a mobile-operating group carry out the aerial reconnaissance (monitoring) of a wildfire on the board of helicopter in order to determine:

- the type of fire;
- scale factors and force;
- the direction of fire movement;
- the characteristics of the land environment and forest area;
- the actual meteorological conditions [3].

However, the available quantity of fire aviation and its location do not ensure the operational efficiency and timeliness of the aerial reconnaissance process throughout our country [1].

The use of unmanned aerial vehicles (drones) that are widely used outside of our country may be an alternative solution for obtaining well-timed and reliable data in the process of leading the aerial reconnaissance (monitoring) of wildfires. Modern drones are equipped with special navigation equipment and can be used in a wide range of temperatures and counteract of wind gusts. In order to transfer video signal in drones cameras are used, images of which are streaming to the dispatcher console in real time. A mobile device (a tablet or a smartphone) can be used in function of console. The distance to which the video signal is transmitted can reach several thousand meters.

The use of unmanned aerial vehicles (drones) by the firefighting officer for aerial reconnaissance (monitoring) will significantly increase the effectiveness of leading of the operational actions in the process of putting out of wildfire.

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CLOSE-TO-NATURE-FORESTRY IN FOREST STANDS OF THE "BUKOVEL" RESORT

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The native forests around the "Bukovel" resort are mainly presented by beeches and also mixes of spruce-fir-beech and beech-fir-spruce. They form numerical bands classified as a mild subcalcareous flysch. The upper mountain forest belt is occupied mainly by spruce forests, only in the contact area of the upper forest belt with the lower beech belt it is mixed with fir and beech. There are few modern natural forest stands. Medieval derivative unstable spruce stands, which haven't been cared for the last 20 years, dominate. The stability of forest stands and individual trees is reduced, that leads to their infesting with mushrooms and entomofauna, drying, clogging and winding processes, and also can lead to injuries of people on the lifts and slopes. Forest stands are actually excluded from normal use and do not allow communities to harvest timber for their own needs. Due to the lack of economic operation, the ecological potential of forests, growing stocks of timber is not used, which is economically unprofitable. Forest protection and forest management activities are not differentiated according to their functions (nature protection and nature conservation, recreation, exploitation) and planting conditions (target, close to the target, distant and derivative). The recreational potential and aesthetic value of forests reduces, and as a result of fragmentation - their hydrological and climate regulating role decreases. If the preventive measures are not implemented the biological sustainability of forests will decrease annually. Long-term program of development and functioning of forests (50-60 years) is necessary for the increase of their sustainability and stability, social role and economic impact. It is essential to order the forests by their purpose and state of the forest stands with further appointment of appropriate measures based on an assessment of all forest functions for particular site.

In the area of the resort complex "Bukovel" prevalent derivatives of the medieval firs require the replacement by mixed forest stands. Now the wood increment is increasing, but it will gradually decrease with age. We must use this potential to increase the plant's sustainability and profitability. The strategic direction of forestry is the harmonious approach. Close-to-nature-forestry is considered as a system of forestry organization and management that ensures the continuous reproduction and formation of forest stands, as much as natural in structure and genesis, and predetermines the constant presence of forest stands at different stages of development and at different levels of vertical and horizontal links in forest areas. It is necessary to conduct a comprehensive and balanced forest management based on the principles of multifunctional forestry taking into account the interests of communities, land and forest users. A dialogue with local communities on the prospects of using forests and the development of a forestry project based on the approach of close-to-nature-forestry is needed. It should be taken into account the direction of natural dynamics and the peculiarities of exogenous natural and man-made impacts. It is important to identify biodiversity in forest areas and to take measures to protect them. The transition from single-age to multi-age forestry involves abandoning the cutting "by area" and concentrating on selecting individual trees, working patiently to create multi-age mixed plantings (several techniques are supposed to be used for a long time). At the same time the timber harvesting should be frequent, but reasonable. Cuttings for care and maintenance of natural regeneration of the same planting should be carried out simultaneously using harvesting techniques and modern technologies of tree harvesting. Cable yarding systems give the opportunity to harvest wood efficiently and qualitatively with minimal impact on the environment. They can be used in the resort forests and leased to forestry enterprises. Such approaches should form the basis for a scientific project for reasoning conservation and forest management activities in the forests within the resort and Polyanytsya forestry.

ENVIRONMENTAL HAZARD OF BURNING DRY GRASS AND GRASSLAND VEGETATION

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The intentional burning of last year's dry grass on suburban meadows and near settlements in the early 2019 became a threatening environmental and technogenic situation. Currently, cases are recorded of people deaths due to the burning of dry vegetation. The fire from dry grass spreads to buildings and structures, and smoke prevents the movement of motor vehicles on national highways (Fig. 1).

Fig. 1 –Dry grass burning near the motorway N 09 (the town of Burshtyn in Ivano-Frankivsk region, 10 March 2019)

It should be noted that along with the combustion products, the substances such as carcinogens, dioxins, heavy metal senter the environment. The representatives of the flora and fauna burn out in the fire. Soil fertility decreases (there occur changes in acidity and mineral composition).The climatic conditions can be favorable factors for the development of dry grass fires. In an arid spring period, the linear rate of dry vegetation combustion increases significantly [1, 2].

In Ukraine, provision is made for administrative and criminal penalties for intentional burning of dry grass and arson of meadow vegetation. According to Art. 77-1 of the Code of Ukraine on Administrative Offenses, the burning of stubble field, meadows, pastures, areas with steppe, wetland and other natural vegetation, vegetation or its remains and fallen leaves in the right-of ways and railroad precincts, in parks, other green plantations and lawns in the settlements without the permission of the state control bodies in the field of environmental protection or in violation of the conditions of this permit, as well as the non-taking by a person, who has received a permit for the burning of the specified vegetation or its remains and fallen leaves, measures for timely extinguishing it - entail imposing a fine on these citizens from ten to twenty tax-free minimum incomes of citizens and on officials - from fifty to seventy tax-free minimum incomes of citizens. The same actions committed within the territories and objects of the nature reserve fund entail imposing a fine on citizens from twenty to forty non-taxable minimum incomes of citizens and on officials - from seven hundred to one hundred tax-free minimum incomes of citizens [3].

According to Art. 245 of the Criminal Code of Ukraine, the destruction of or damage to forest areas, green plantations around settlements, along the railways, as well as stubble field, dry indigenous herbs, vegetation or its remains on agricultural lands by fire or other dangerous method - shall be punishable by a fine of three hundred to five hundred tax-free minimum incomes, or restriction of liberty for a term of two to five years, or imprisonment for the same term. The same actions, if they caused the death of people, massive death of animals or other grave consequences, shall be punishable by imprisonment for a term of five to ten years [4].

Thus, in addition to fire, environmental, technogenic threats to the environment and people's life and health, intentional burning of dry grass can lead to the imposition of administrative and criminal penalties for arsonists.

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LOCALIZATION OF FOREST FIRES

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10.8 million hectares of forests and peatlands are located on the territory of Ukraine, which is 15.6% of its total area [1]. This raises the problem of forest fires, which annually registers from 3 to 7 thousand, which leads to the destruction of more than 5 thousand hectares of forest [1]. Therefore, the main problem is the timely detection and localization of forest fires, which makes it possible to significantly reduce losses and thus protect the biological environment of the country. Questions on the implementation of the tactics of forest fires localization at the present stage are not sufficiently disclosed. Therefore, in most cases, there is a problem for promptly making a reasonable decision for the implementation of the localization tactics and, accordingly, the extinguishment of forest fires. The main factor that influences to the process of successful implementation of localization tactics and forest fire suppression is the definition of the total length of the edge of the fire $L_{l.p}$

$$L_{\ddot{e}.\ddot{\imath}} = \left(\bigcup_{³=1}^{²} L_{\ddot{E}³}\right) \bigcup \left(\bigcup_{j=1}^{J} L_{\acute{A}j}\right) \bigcup \left(\bigcup_{q=1}^{Q} L_{Đq}\right) \bigcup \left(\bigcup_{g=1}^{G} L_{\tilde{A}g}\right), \quad (1)$$

where $\bigcup_{³=1}^{²} L_{\ddot{E}³}$ - the length of artificial localization barriers with their total number of *I*; $\bigcup_{j=1}^{J} L_{\acute{A}j}$ - length of existing barriers of natural origin with their total quantity *J*; $\bigcup_{q=1}^{Q} L_{Đq}$ - the length of existing fractures of the fire edge with their total number of *Q*; $\bigcup_{g=1}^{G} L_{\tilde{A}g}$ - the length of the edge of the forest fire without localization barriers and rupture of the fire edge in the total number of these areas *G*.

To accomplish this goal, the following tasks were solved:

1. A method for determining the total length of natural localization barriers and rupture of the fire edge in the fractions of the perimeter of the fire is developed.

2. The number of units for the implementation of artificial localization barriers and the time of its follow-up to the place of fire have been determined.

3. Time and linear speed of implementation of artificial localization barriers and their distance from the edge of the fire are determined.

The obtained dependencies have made it possible to establish that the type of forest drought is primarily affected by the rate of distribution of the fire edge. At maximum forest drought, in comparison with its minimum value, the rate of distribution of the forest fire edge increases to five times.

The dependence is obtained for determining the distance of the localization line to the limit of fire on the normal to the edge of the fire and this distance can not be less than 50 m.

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SPECIES DIVERSITY OF MICROMYCETES FUNGI AS A CRITERION EVALUATION OF RESTORATION DISTURBED SOILS

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An important task of cenototic research within anthropogenic disturbed territories is the study of successions of fungi on self-sustaining and re-cultivated territories (sulfur and amber extraction). Ground fungi differ in type of nutrition and in interaction with other organisms. Among them are saprophytes, destroying plant and animal remains, plant parasites (optional or obligate), mycorrhiza, and also fungi-predators. Fungi play an important role in the transformation of organic compounds - a schedule of cellulose, lignin and pectin substances; the cycle of nitrogen, in particular during the processes of ammoniation, which contributes to the formation of conditions for the development of other microorganisms. In addition, soil fungi are able to produce a variety of biologically active substances: amino acids, enzymes, lipids, polysaccharides, antibiotics, plant growth promoters, vitamins and toxic substances. It is known that on disturbed territories, the restoration of fungal groups occurs gradually under the influence of abiotic and biotic factors. Insufficiently studied is the process by which permanent changes in plant groups cause changes in the soil - the micro-organisms habitat, and, consequently, in their functioning. The influence of plant groups on the composition of microorganisms in organic fall and soil is clearly traced. It was investigated that the bulk (70-80%) of vegetative decay can be decomposed by fungi. Microscopic fungi, as one of the main components of the soil biocenose, are sensitive to changes in soil properties, and are therefore used as test objects for the study of modified soils.

Microorganisms play an extremely important role, not only in soil formation and in maintaining soil fertility, but also help plants absorb the inaccessible elements from the soil layer, thereby improving their functioning and further development. The presence in the soil ecosystems the most diverse groups of microorganisms, causes their enormous importance in the soil-forming processes.

During the vegetation period, 11 soil samples were selected within the limits of the Yavoriv sulfur quarry, of which about 5391 isolates of fungi were isolated in the culture.

The obtained data indicate that the biodiversity of soil fungi on the plots within underground extraction I is significantly higher (number of species, frequency of occurrence) and makes up 43 species, compared to plots within underground mining II (28 species) and in areas within the dam (20 species). All typical types of soil micromycetes are divided into two groups. The first group includes species sensitive to anthropogenic loading (disappearing on technosomes and embryos, dominated in the best soil conditions), the second - species, indicative for technosomes and embryos (the rank of dominance is sharply manifested in technosomes and embryos). The first group includes fungi-epiphytes, phytopathogens, or species that develop on plantremnants that are spread out in the soil. Probably, the decrease in the reproduction rate of these species is associated with inhibition of the growth and development of plants in polluted territories of gray. The second group of fungi species has the highest indicative value. These species, atypical, or rarely found on the control, actively synthesize toxins with antibiotic, fungicidal, phytotoxic and zootic action. This ability of metabolism allows them to dominate under conditions of anthropogenic pressure in a competitive struggle against other types of fungi. In addition, many of these species contain dark pigments that have antioxidant properties that protect against drying and high insolation.

Based on the fungi identification, in soil samples 62 species of fungi and one species of *Pseudomonas denitrificans* Bergey, which are involved in fixation of nitrogen, were identified. All types of fungi belong to 9 orders, 11 families of 5 classes and 2 departments. The richest species composition is the *Deuteromycotina* subdivision, which includes 2 classes (*Caelomycetes* i *Hyphomycetes*). Among the representatives of the order of *Helotiales* dominated species of the family *Sclerotiniaceae, Trichocomaceae*. Species of the genus *Penicillium* (23 species) are dominant among them. The highest biological diversity is characterized by soil mycobiote on the underground mining of sulfur I, where the species composition of soil fungi is 43 species. Areas in the underground mining of sulfur II are characterized by the presence of 28 species. The smallest species diversity of mykobiota was formed on the territory within the dam with the presence of 20 species, including the bacteria *Pseudomonas denitrificans,* involved in soil formation.

Formation of a complex of typical types of micromycetes is determined by the laws of soils origin. This confirms the possibility of using a complex of micromycetes to characterize the formed soil mixtures based on their species diversity.

We have carried out a calculation of the incidence rate for all types of fungi of micromycetes, but only those that were more commonly found in studied ecotopes were used for the analysis. It was established that the following species, such as *Penicillium digitatum* (31,5%), *Aureobasidium pullulans* (18,5%), occur more frequently on the plot within the limits of underground mining of sulfur I. Within the underground mining II, *Rhizopus oryzae* (28.9%) *Rhizopus stolonifer* (15,4%), *Rhizopus oryzae* (18,5%) is most commonly found on plots within the dam.

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LOGISTICAL AND TECHNICAL ASPECTS OF ENSURING THE FIRES SUPPRESSION IN ECOSYSTEM

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The current development of science and technology throughout the globe undoubtedly contributes to improving the lives of people. Today, society is capable of producing and exploiting things that have been considering beyond human capabilities even a couple of decades ago. At the same time, however, there is a situation of environmental degradation and the increasing occurrence of natural emergencies, accompanied by a large number of human casualties and the attraction of significant material resources to overcome their consequences.

One of the striking examples of such emergencies is the devastating forest fires, including fires that occurred in the summer of 2018 in the United States. Accordingly, to statistics [1], more than 2.9 billion dollars have spent on forest fire extinguishing last year, which is 12 times more comparing than in 1985. In general, statistical data shows that more and more money is spending every year on forest fire extinguishing.

Partly the expenses of this amount of money could be explained by the involvement of a significant number of people and technical equipment. As a rule, during the wildfires, the large areas and territories are occupied with fire, the extinguishing of which requires a large number of firefighters, volunteers, etc., who are called to conduct direct extinguishing, the creation of artificial fire barriers and organization of evacuation of the population who is in danger of a fire. Accordingly, to statistics this year in California, USA [2] was involved 12,000 workers in 17 large wildfires.

Involving such a number of personnel requires from a headquarters to create and maintain a comfortable environment for people to rest and to further firefighting tactic in order to eliminate the wildfire.

Proceeding from the safety requirements, the short-term camp should be located no closer than 100 m from the wildfire on the part of the extinguished flanking edge of the fire and surrounded by a mineralized strip. However, in most cases, during wildfire extinguishing, there is a need to organize a camp, which at the same time will be the management headquarters of the fire extinguishing. Such a camp should be located on a dry ventilated area, preferably near the water resource and at a safe distance from the fire. In order to organize the camp and create conveniences for work and residence, the head of the camp should be appointed. He must correctly arrange the camp, equip it with the observance of safety and sanitation rules.

The camp should accommodate a tent camp, a kitchen, a warehouse of products, firefighting stock equipment and centre of the radio connection and communication, management headquarters. Not far from, at some distance, should be located a parking lot, a helicopter ground, a toilet.

Modern life support systems of the personnel in field conditions can not only provide the basic needs of people but also bring them to the highest level [3, 4].

Thus, in order to ensure a comfortable stay of the personnel in the camp today, a significant number of manufacturers offer the following mobile life support systems (Fig. 1.). The main advantage of these systems is the high mobility and autonomy of work due to the connection of autonomous power systems to them.

a) mobile sanitary system b) mobile laundry c) mobile air conditioning system

Figure 1. Modular life support systems

The sanitary container is a mobile, heat-insulated 20-foot container based on a refrigerated container, equipped with six toilets, two urinals and two washbasins. This container was designed for quick and flexible use during the long period of exploitation. It is equipped with air conditioning and heating, ensuring use of the toilet container even in adverse climatic conditions. The design and stainless steel material of the interior furnishings enable fast and highly efficient cleaning of surfaces so that the highest hygiene standards are satisfied even in field conditions. What is more, the reefer container's excellent insulation keeps the energy consumption for heating and air conditioning low, whatever the climate.

The mobile laundry container for laundry can be mounted on a trailer or container containing six washing machines and six dryers that are used for washing and drying a lot of linen.

Mobile air conditioner, which is used for cooling and drainage of tents and other places of people's stay, the cooling capacity of 18 kW.

Provision of rescue units with similar equipment can significantly reduce the time of making operational decisions and increase the efficiency of staffing.

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A METHOD OF LIMITING THE SPREAD OF PEAT FIRES

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Peat fires occur in different countries of the world, in particular, the USA, Canada, Great Britain, Ukraine, Republic of Belarus, India, and others. When fighting such fires all over the planet, people are faced with the same problems. Peat burning is accompanied with a pollution of the environment. That is why the emissions from peat fires can become a significant environmental problem. As a rule, such fires are very large and need the utilization of a large amount of human and material resources.

The aim of present study is to identify the patterns of geometrical parameters of barriers to the propagation of fires in peatlands and their fire-retardant capacity to serve the scientific basis for creating a new method to restrain fires in peatlands.

To accomplish the aim, the following tasks have been set:

– to perform mathematical modeling of thermal processes in the system peat layer – fire barrier;

– to determine the time of reaching the dangerous temperature in a peat layer depending on the thickness of a barrier;

– to devise a procedure for designing fire protection barriers made of mineral materials.

To solve the set tasks on the prediction of behavior of the system peat layer – barrier, it is required to devise a procedure for determining temperature distributions in layers of a peat layer and in the proposed barrier. A thermal problem on heat propagation in the described system can be stated as follows.

1. A fire in a peatland extends from top to bottom with a certain constant speed.

2. Temperature in the region where peat is fully burned is constant, and it equals a mean constant value.

3. Thermal-physical properties of peat and the material of the barrier may depend on temperature.

4. Temperature in the region of peat burning is constant.

5. Heat transfer between the region of the underground fire and the material of the firefighting barrier has only a radiant component because its share is dominating.

6. A condition for the ignition and onset of fire propagation in a peat layer, which is protected by the fireproof barrier, is that the temperature of ignition in the respective estimated region has been exceeded.

Initial data that are employed in line with [3] for calculations are compiled in Table 1.

Table 1
Initial data for the calculation of temperature distribution in the system peat layer – fireproof barrier

Initial temperature of layer, ºC	Temperature of surrounding air, ºC	Temperature of peat burning, ºC	Temperature of peat ignition, ºC	Temperature in the center of peat fire, ºC	Degree of blackness of the barrier surface	Degree of blackness of soil surface	Heat exchange coefficient between soil and air W/(m·ºC)	Speed of propagation of the front of peat burning, mm/min
20	20	475	225	720	0.7	0.9	9	2

Thermal-physical characteristics of peat and materials of a fireproof barrier are given in Table 2.

Table 2
Thermal-physical characteristics of peat and materials of a fireproof barrier

Coefficient of thermal conductivity $\lambda(T)$, W/(m·°C)	Specific heat capacity, $c_p(T)$, J/(kg·°C)	Density, kg/m^3
Thermal-physical characteristics of peat		
$\lambda=(0.585-0.495W+0.987W^2)\ T^{0,2}$	$c_p=(765.0–1{,}577.8W)\times\exp[(0.64\ 10^{-3}+0.0175W)T]$	400
Thermal-physical characteristics of sand		
1.9	1,700	1,650
Thermal-physical characteristics of bentonite clay		
0.7	2,500	1,360

Thermal-physical properties of peat and materials of a fireproof barrier can be accepted according to recommendations [3–6].

The equation of nonstationary thermal conductivity for a given case has no analytical solutions and can be solved only numerically [7, 8, 9]. A method of finite elements was used to solve it [8, 9]. Its implementation is carried out in accordance with the developed estimation procedure. According to this procedure, estimation is performed using the following procedures.

When designing fireproof barriers for peat layers, their thickness is an important parameter. That is why, in the case of automated selection with respect to time that is required to provide for the protection of a certain area of the peat layer, it is proposed to employ a regression analysis. The formula we obtained could be applied for solving the above problem.

To perform a regression analysis, it is proposed to use a polynomial of the third order; such a choice is predetermined by the shape of curves. Parameters for the regression dependence were obtained using the Newton method. Table 3 gives the obtained parameters of regression functionals.

Table 3
Parameters of regression dependences of thickness of a barrier on time, which is required to provide for the protection of a peat layer

Regression coefficients $b=a_0+a_1\tau+a_2\tau^2+a_3\tau^3$	a_0	a_1	a_2	a_3, $\times10^{-3}$	Error, %
Barrier made of river sand	–141.526	31.406	–0.681	5.319	0.5
Barrier made of bentonite clay	–106.429	14.653	–0.149	0.692	0.4

Fig. 1 shows charts of the obtained regression dependences.

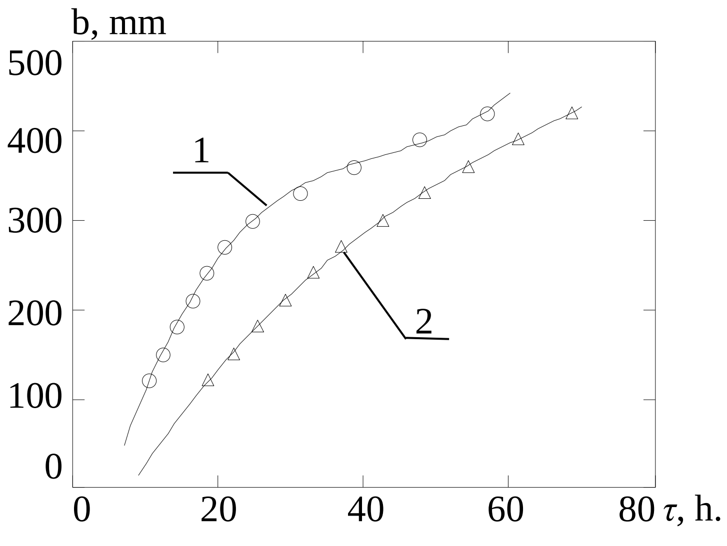

Fig. 1. Regression dependences of thickness of a barrier on the time, required for the protection of site of a peat layer: 1 – made of river sand; 2 – made of bentonite clay

The regression dependences obtained have some limits for practical application. These dependences hold in the intervals of the time required to protect a section of a peat layer for the barrier made of river sand, from 3 to 60 hours; for the barrier made of bentonite clay – from 5 to 70 hours. For the time values that are smaller than the smallest extreme value of the respective intervals, it is technically impossible to build such barriers as there are no standard equipment for such tasks. As regards the values that are larger than the highest extreme values for respective intervals, the construction of such barriers is impractical because rescue squads would necessarily arrive within such a time period and localize the fire.

Research results could be applied when designing fireproof barriers for actual peatlands. At the same time, from the economic viewpoint, it is necessary to consider a possibility to use materials that are available in the region of peatland location. That is why there is a need to conduct further study to investigate the use of other mineralized materials as a filler for a barrier.

Conclusions

1. We identified as the result of mathematical modeling of thermal processes in the system peat layer – fireproof protection the patterns in the time of reaching the dangerous temperature in a peat layer that was protected. It was established that the time of reaching the dangerous temperature in a peat layer for the barriers made of river sand and bentonite clay is not less than 1 day from the onset of action of the burning temperature.

2. In order to find the time of reaching the dangerous temperature in a peat layer depending on the thickness of a barrier, we constructed regression dependences. By using mathematical modeling of the processes of fire development, we established a parabolic dependence of thickness of a fireproof barrier b, mm, on time τ, hours, which is required to provide protection of an object. The dependence can be described by polynomial regression functions $b=-141.526+31.406\tau-0.681\tau^2+5.319\tau^3$ – in the case of using river sand, and $b=-106.429+14.653\tau-0.149\tau^2+0.692\tau^3$ – in the case of using a 10-% suspension of bentonite clay.

3. Based on the results of our study, we devised a procedure for building fireproof barriers, in order to fill the fireproof gaps in peatlands, with a width from 180 to 300 mm made of a 10-% water-clay suspension based on bentonite clay, or river sand with a grain module less than 1.48.

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INFLUENCE OF GLOBAL CLIMATIC CHANGE ON THE FIRES RISKS OF THE NATURAL ECOSYSTEMS

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Global climate changes in particular in Ukraine, leads to an increase on the lasting of the fire danger season. Climate change affects forest fires both directly through the weather conditions that affect fire ignition and propagation, and indirectly through its effects on vegetation and fuels. The main cause of forest fires is the violation of the fire safety requirements in forests during the period of high emergencies and the burning of vegetation on agricultural lands. The fires on agricultural land in Ukraine are an annual recurring fact. They cover most of the plains of Ukraine and occur throughout the fire danger season. Such fires threaten the local population, infrastructure and the environment; in particular, they lead to massive carbon emissions and forest fires.

The fire danger in the forest masses also increases under the influence of the human factor and weather conditions in the spring and late summer. Enterprises of the State Forest Resources Agency of Ukraine systematically carry out preventive and educative work among the local population on compliance with fire safety requirements in forests, detection of violators of these requirements and bringing them to administrative liability.

During the last days in the Lviv region, due to the sharp warming, the number of dry grass firings increased significantly. In particular, only during March 7, 2019, State Emergency Service of Ukraine units in the Lviv region for 35 times carried out to eliminate such fires.

Grass is a fine vegetation type and fire burns through it faster than forest. Grassfires spread very quickly; sometimes their speed can be carried up to 25 km per hour. They can generate enormous amounts of heat. The taller and drier the grass, the more intensely it burns. An average flame height from a grassfire would be between 2 to 5 meters. Grassland area with dried, brown or golden colored grass, with a height of more than 10 cm, can be a bushfire risk. Short grass under 10 cm is much lower risk. The shorter the grass, the lower the flame height and easier the fire is to control. Grassland includes pasture, crops, open native grassy woodland as well as those areas of open space in and around the suburbs. Grassfires can start accidentally when using machinery such as chainsaws, lawnmowers, tractors, grinders and welders. The hot exhaust of a vehicle parked on a road verge or driving through long, dry grass can start a grassfire. Grass fires can start quickly and spread rapidly, catching people off-guard. Grass fires are very hot and can produce huge amounts of heat that can kill anyone caught out in the open.

Particularly dangerous is the burning of dry grass in the fields, through which pass high-voltage power lines, near the forest massifs, gas stations. The rate of fire propagation is extremely high, so it is very difficult to locate such fires in open areas.

Due to the effects of global warming, should expect further increase in the number of extreme weather events such as fluctuating winds, droughts, abnormally heavy showers, storms, lightning, etc. This will increase the level of fire danger in forests and agricultural lands. In order to minimize all these risks, should be pay special attention to the fire prevention of forest fund lands, to ensure the readiness check of the personnel and technical equipment of the units involved in eliminating fires. In order to prevent and spread the landscape fires it is necessary to lead up regular trainings at the enterprises of the State Forestry Agency and the development of interaction of forest fire services of the State Forestry Enterprises with the relevant units of the State Emergency Service of Ukraine.

Nowadays, the issue of preventing, detecting and eliminating fires keeps on an extremely important issue on agricultural lands. In most cases the grass fires pass into forest fires. It should also be noted that the unclear nature of the prohibition of agricultural burnings and the lack of specific law norms about the responsibilities of landowners and land users in relation to the responsibility for preventing fires do not too promote to reducing the excessive number of such fires in Ukraine and in Lviv region in particular.

Forest fires are complex phenomena caused by a combination of land management, human activities, cultural traditions, and climate and weather conditions. Unfortunately, the lack of reliable statistical data on landscape fires, imperfect legislative framework, poor financing, insufficient coverage of this problem in the society do not allow to reduce the risks of their occurrence in Ukraine.

Climate change affects forest fires both directly through the weather conditions that affect fire ignition and propagation, and indirectly through its effects on vegetation and fuels.

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THE EFFECT FROM DRY GRASS ARSONS ON THE POPULATION OF AMPHIBIANS AND REPTILES IN OPILLIA (LVIV OBLAST)

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The burning of dry grass occurs by malicious people on a regular basis. There is a negative impact on the local fauna of amphibians and reptiles. Runaway causes the degradation of local biotopes and lead to a decrease in the number of animals and their trauma.

The purpose of our research was to determine the list of species of amphibians and reptiles affected by natural grass firing in the spring in the territory of the natural area of Opilia, located in the Pustomyty raion of Lviv Oblast. Data were collected during 2004-2019.

Plots where the dry grass is burned each year are located near the villages of Solonka, Kovyri, Lypnyky, Zagirya, Kugayiv, Rakovets, Derevach. Most often, the fires were recorded on the ground of former pastures, in natural garbage dumps and near them, in the valley of the Zubra River. Conflagrations cover open areas and reach the contact zone of forests, but do not extend into the depths.

It is the contact area of the forest and open space that is most populated by amphibians and reptiles in the spring. The tritons and brown frogs migrate from the winter storage to the reservoirs outside the forest.

In Opillia, carpathian newt (*Lissotriton montandoni*), alpine newt (*Ichthyosaura alpestris*), northern crested newt (*Triturus cristatus*), common newt (*L. vulgaris*) are moved to the open waters that are warmed by the sun.

The first two species also populate the shaded and slightly warmed spawning grounds in the forests, so in their populations, burning dry grass does not exert significant pressure. The fires complicate the transition of northern crested newt and common newt from the forest to water.

If arson occurs at dusk (during mass transitions), the death of newts during an approaching fire is not excluded, since they cannot escape.Tree frog (*Hyla orientalis*), common frog (*Rana temporaria*), and common toad (*Bufo bufo*), in contrast to smaller tritons, are able to overcome long distances in a shorter time, however, and for them a quick fire offensive often becomes a cause of injuries and burns. This is confirmed by our numerous observations, during which we found dead and crippled adults. The injured and dead amphibians become easy prey for predatory and omnivorous birds and animals. Shortly after the fire – birds (ravens, jays) find plenty of nutrition.

Among the reptiles that suffer from fires, there are: Lacerta agilis and the viviparous lizard (*Zootoca vivipara*), the grass snake (*Natrix natrix*), blindworm (*Anguis fragilis*) and the common european viper (*Vipera berus*). These animals usually are not destroyed by fire. However, individuals with signs of thermal damage were registered practically everywhere in the research area. Because reptiles are capable of rapid movement and can hide in the burrows of rodents, their own repositories, under the stones, in shelters of another type – there they are able to save their own lives.

After passing the fire, within one to two weeks, lizards and snakes are not able to fully demonstrate their sexual behaviour and feed themselves. Many small animals that feed reptiles are destroyed by fire. Thus, the feed base in the spring as a result of anthropogenic impact is impoverished.

Therefore, as a rule, the proportion of dead and injured amphibians and reptiles as a result of burning the grass is not high, however, all local species are affected. Some individuals die and receive thermal burns.

There is a temporary deterioration of the migratory route from the places of wintering to spawning reservoirs. The movement through the burned area is difficult, the ashes stick on the surface of the body of amphibians and worsens skin breathing.

In burned territories, amphibians and reptiles become easy prey for predators. This is due to a significant reduction in the number of shelters from stems and leaves of herbaceous plants.

Among the intruders we found, were teenagers and the elderly. Their reaction to comments in most cases was accompanied by aggression. And, as a result, dozens of hectares of dry grass faded annually in a matter of minutes.

The magnitude of the impact on the population of amphibians and reptiles is assessed visually. The proportion of dead and injured animals depends on the date of fire, weather and time of day. According to our observations over the past 15 years, as a result of fire every year, there were negative changes in the habitat and migratory route of amphibians and reptiles. Arsons have a direct and indirect effect on the population of amphibians and reptiles and only lead to negative consequences.

ON ANTHROPOGENIC DANGER OF ROCK DUMPS

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Mining and use of fuel and energy resources result in huge volumes of wastes becoming large-scale anthropogenic sources of permanent negative influence on environment components in most cases. According to the statistics data, wastes of mining industry take down the greatest part of all wastes in Ukraine and figure up to 73.6%.

Location of wastes in environment results in alienation of large territories and arising of hazard of emergency situations caused by a man-made impact. Coal mining wastes is a source of contamination of atmospheric air, soils, surface and ground waters. They also have huge negative impact on the state of peoples' health and plants. Official statistics shows that the level of respiratory deceases is much higher for people living in the territories of wastes location than that of living in other places because wastes storage comes with multistage physical and chemical processes and emissions of harmful substances into the environment caused by them.

The problem is now urgent for all mining regions of Ukraine, particularly for Chervonograd mining and industrial region (CMIR) being a part of Lviv-Volyn Coal Basin. This territory is the location of hard coal mining in relatively small 180 km^2 area for more than 50 years. Coal mining in CMIR takes place in 12 mines. The depth of coal bed ranges between 300-600 m. Thin and average beds were mined in the region by means of board-and-pillar method with pillars working out in reverse direction. As for now 5 mines are closed in the region (№1 "Chervonohradska", "Vizejska", №5 Velykomostivska, Bendiuzka, "Zarichna"). Waste rock of those mines was utilized for bore backfill and roads filling. Circa 561.5 hectares of lands comprises the area of negative influence of mining enterprises, rocks wastes take 137,5 hectares, which is about 25% of total area of mining concession.

Mining of coal in mines was carried out without filling worn space with waste rock. This resulted in huge volumes of waste rock on the territory becoming one of the most problems as waste rocks store 85 mln m^3 of coal mining wastes and 14 mln m^3 of coarse fraction and 12 mln m^3 of fine fraction of by-product coal.

Spoil fire and waste rock treatment should be considered as unsolved problems of the region. For example, plot of glowing embers was observed in closed "Vizejska" mine with the temperature reaching 128°C and "Chervonohradska" mine, 137°C. But the most serious hazard for the environment in the region is caused by waste rock of PJSC "Lvivska Vuhilna Companija" (Central dressing facility) with total area of 882 thousand m^2. The territory was under active combustion resulting from departing from "The Instruction on Self-ignition Prevention, Extinguishing and Knocking down of Waste Rocks". The Instruction requires that rock storage should imply wastes sandwiching by clay and soil (sand), strictly forbids charging of rock mass on combustion areas. But the measures were not taken, which resulted in anthropogenic catastrophe in the region. Moreover, during the primary stage of fire liquidation only water was used, even though the "Instruction…" requires that fire fighting starts from moistening with water aimed at cooling of rocks surface layer on 0.1-0.2 m depth to the temperature below 80ºC. The water expenditure is considered as no less than 50 l per m^2 of burning surface. But modern procedures of waste banks extinguishing require adding of lime grout. This enables blocking of microbiological processes and thus possibility of reigniting decreases sharply. Extinguishing with water provides some result, but it is insignificant, as 90% of water becomes evaporated.

We believe that the all regulatory instruments in Ukraine concerning treatment of coal mining industry wastes should be revised, as they mostly do not provide application of modern technology of liquidation of negative consequences of influence on environment and do not state any strict requirements on treatment of coal mining industry wastes.

The following tips are recommended to reduce the ecological hazards of coal mining wastes:

- strict regulatory approval system of cumulating and exploitation of rock waste and amenability in case of its neglecting;
- clear determination of legal successor for rock waste in case liquidation of mine;
- availability of information about negative influence of the wastes on all environment components, particularly human;
- monitoring system of the objects not only during the exploitation period, but also in case they are closed;
- providing system of financial assurance for territories rehabilitation after negative influence on environment;
- development of system of security control for emergency states on the objects;
- systematic control of the objects by state authorities.

BURNING OF DRY MEADOW VEGETATION AS A SOURCE OF LANDFILL SITE COMBUSTION

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Burning dry vegetation on agricultural lands of Lviv region in 2019 reached catastrophic proportions. One of the factors contributing to the development of landscape fires is the climatic and temperature conditions [1].Along with the environmental impacts that result from burning dry grass, one of the most serious threats, it should be noted, is the fire spreading to other objects of economic activity. In Ukraine, in 2019, there were recorded cases of fires in residential and country houses, auxiliary premises that arose as a result of the arson of last year's dry vegetation. One of such cases is the combustion of the Novoyavoriv landfill, in order to extinguish this fire, the units of the rescue and firefighting service were involved (Fig. 1-3).

Fig. 1- The Novoyavoriv landfill combustion in Lviv region due to burning dry grass

Fig. 2. Involvement of the rescue and firefighting units to extinguish the Novoyavoriv landfill fire in Lviv region

Fig. 3 - Extinguishing the Novoyavoriv landfill burning in Lviv region

As a result of household was tecombustion, large amounts of toxic substances are produced that exceed the maximum permissible concentrations and can cause poisoning of the human body even in the open [2].Polymeric materials are the dominant type of waste in landfills and polygons of solid household waste. When heated to a temperature of + 300-500 ^{o} C, their ignition occurs. During the heating and flaming combustion of polymers, hazardous substances are formed such as phosgene ($COCl_2$), cyanide hydrogen (HCN), hydrogen sulfide (H_2S), chlorinated hydrogen (HCl), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2) and others. [3].

The products of garbage combustion contain chlorinated dibenzodioxins and dibenzofurans in concentrations up to 14 ng / m^3 and more (at values of maximum permissible concentrations in the USA – 0.02 ng / m^3, in the Netherlands – 0.024 ng / m^3, in Italy – 0.04 ng / m^3 [4].Toxic components of harmful emissions from landfills and solid household waste polygons directly affect humans, animals, vegetation which are in close proximity to garbage storage and in the background zone.The hemoglobin-bound CO is gradually secreted into the blood which, in a healthy person, is cleared of CO by 50% every 3-4 hours.The effect of CO on the central nervous system manifests itself in changing the color sensitivity of the eyes.The maximum one-time permissible concentration of this substance in settlements is 3 mg / m^3.

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ANALYSIS OF WILDFIRES IN LVIV REGION

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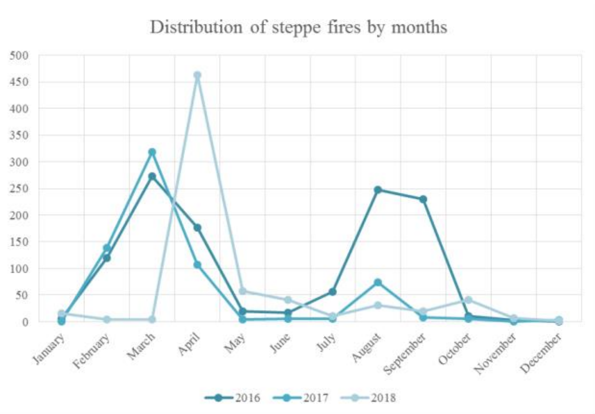
Wildfires include forest fires, peat fires, steppe fires (vegetation and grass fires), agricultural fieldfires, fires in solid waste landfills and others. The combustion of plants, peats and especially solid waste, is accompanied by the formation of toxic combustion products that settle in soil and water. Moreover, toxic combustion products can cause respiratory diseases and cancer in humans. To investigate the causes of the wildfires it is necessary to analyze the distribution of their time occurrence and dependence of different factors. For the analysis we have selected statistics for the last 3 years. The diagrams show the distribution of the occurrence of steppe fires, peat fires, forest fires and fires in landfills in Lviv region.



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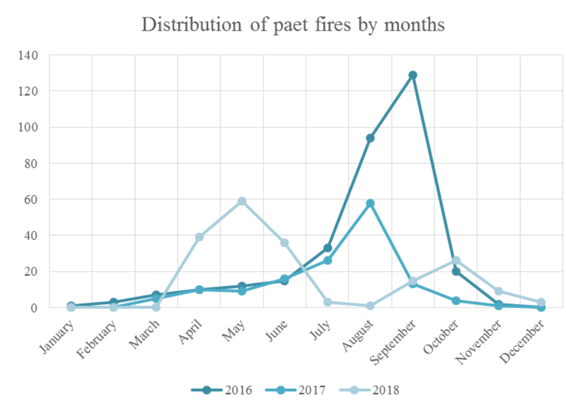

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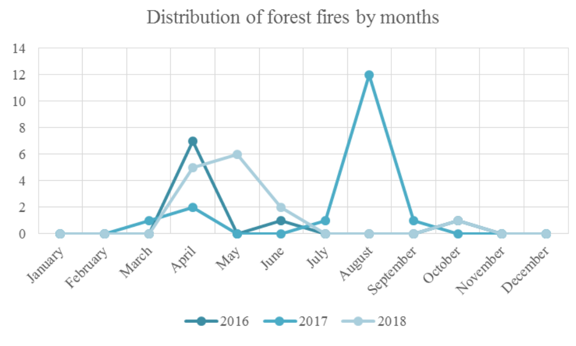

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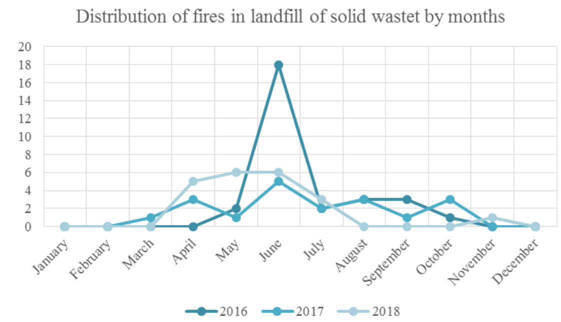
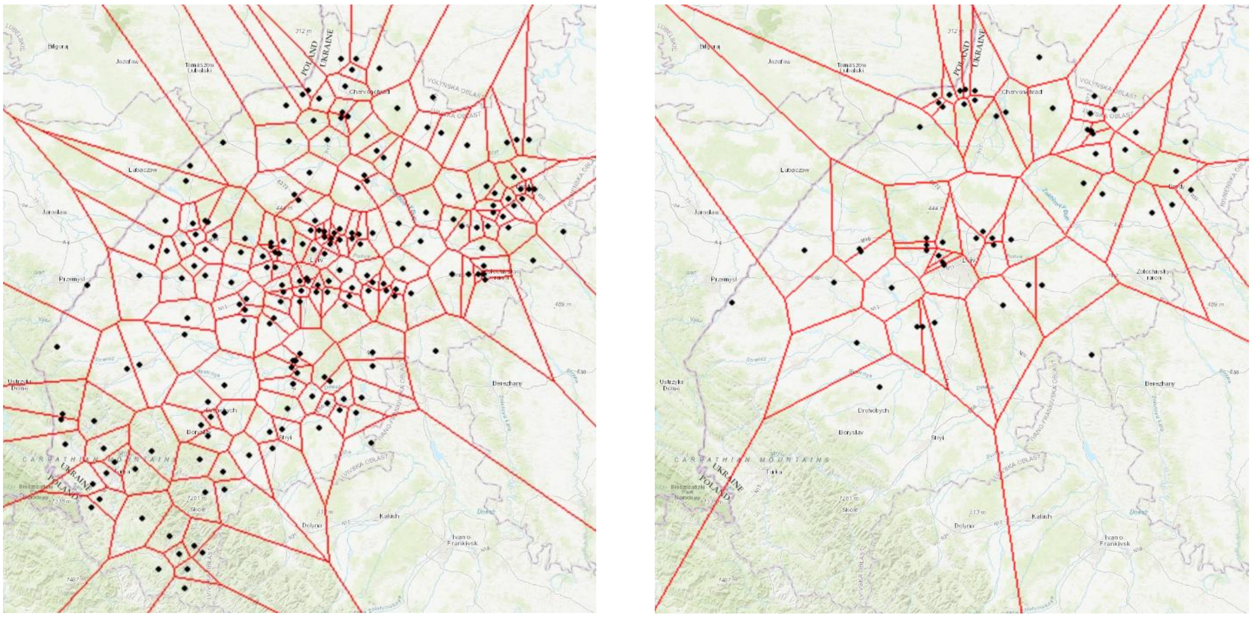


d)

Figure 1 —Distributions of fires by months in Lviv region: a) steppe fires; b) peat fires; c) forest fires; d) landfill fires

As we can see from the diagrams, there is no close correlation for the last 3 years between the number of fires and months. The peak of fires in Lviv region usually occurs at the beginning of the fire danger period and after the harvest. The largest correlation is observed between the number of fires in landfills and months.

In order to investigate the distribution of fires in Lviv region, we have constructed Voronoi diagrams for the wildfires to identify the most dangerous and safe areas. Figure 2 shows the diagram of Voronoi by the place of steppe and peat fires.



a) b)

Figure 2 —Voronoi diagram by place of wildfires: a) steppe fires; b) peat fires

We have also analyzed the influence of climatic conditions on wildfires depending on, namely: average monthly temperature, maximum monthly temperature, average monthly humidity and minimum monthly humidity. According to the results of the analysis, it is established that the largest correlation is observed between climatic indicators and the occurrence of fires in landfills.

The impact of wildfires on the environment is being studied globally. According to the article [1], wildfires and increase of the daily wildfire-specific lead to increased risk of respiratory diseases in humans. In the work [2] the influence of pollutants on the risk of respiratory illness and asthma in children is established. The scientists went even further into their research [3] as they have found the impact of wildfires on increase the weight of newborn male children.

The investigation of peat fires is also often practiced around the world. In the paper [4] the results of mathematical modeling of peat fires are presented. As per article [5] scientists have investigated the temperature regimes during peat fire at different depths and spread of fire around the area.

The effects of landfill fires on the environment and human health is less studied in the literature. Scientists from Nigeria have established the composition of waste in landfills and the composition of combustion products released into the atmosphere by burning [6]. The composition of combustion products is also considered by observations of their concentration during the fire, during extinction and after extinction of landfill fire in northern Canada [7]. Studies in the United States have focus on the study of tire fires in the landfill.

Conclusion. The composition of garbage in landfills and the composition of garbage combustion products in different countries is different. It is caused by environmental legislation, climate, etc. Therefore, the study of landfill fires is a perspective area of research.

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HEAT RESISTANCE OF SHRUB SPECIES OF JUNIPER IN STREET PLANTINGS OF THE URBAN ENVIRONMENT

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In urban environment conditions, which are characterized by an increased average annual temperature of the air and soil, low humidity, an important criterion required for street vegetation is the level of heat resistance. This is considered to mean resistance to overheating caused in the natural environment by high levels of direct and diffused insolation (high temperatures).In this case, a "threshold" temperature level is distinguished beyond which the processes of metabolism and energy redistribution get disrupted. This level of heat resistance is within 40-60 ^{o}C. The vegetation in urban conditions, adapting to the environment, gradually developed the ability to withstand these "stress" temperature conditions. Therefore, each biomorphological group of plants is characterized by its own level of heat resistance.

To study heat resistance of shrub species of the genus *Juniperus* [3], the method of physiologist F.M. Matskov was used in laboratory conditions. It is based on the property of plant protoplasm to withstand high temperatures [1]

In the case of plant cells dying off and prolonged coagulation of protoplasmic proteins, hydrochloric acid, which is an analogue of insolation heating, penetrates into the middle of the cell, forcing a mobile molecule of magnesium out of chlorophyll. The substance of brown color is formed which is called pheophytin. This process is known as "*pheophytin burst* " [2].The degree of heat resistance was evaluated, in the area of brown spots on the affected surface of the plant, on a 5-point scale.

The study was carried out as follows: a water bath was heated in a series of several times within a temperature range of 40-80 ° C. Each time, a bundle of tied 10 shoots of the study species was immersed in the bath. The heating continued for 30 minutes. After that, a shoot of each species was taken out of the bath and transferred into the crystallization vessel for cooling. Then the temperature in the water bath was raised with increasing the heating time interval by 10 minutes, followed by placing the group of shoots into the crystallization vessel for cooling. The shoots, which were cooled for 5 minutes, were placed into separate vessels with a 0.2 N solution of hydrochloric acid (HCl) for 20 minutes. The surfaces of the shoots got covered in varying degrees, depending on the species, with brown spots - the above-mentioned pheophytization took place. The results are presented in Table 1.

Table 1

Assessment of heat resistance levels according to pheophytization

Species	Coloration and type of needles	Degree of needle pheophytization depending on temperature, ^{o}C					Group of resistance to fading
		40	50	60	70	80	
J.sabina ‘Cupressifolia’	dark green, scaly	+	+	++	+++	+++	I
J.conferta ‘Schlager’	light green, needle-like	++	+++	+++	+++	+++	III

J. media 'Gold Star'	golden-green, combined	+	+	++	+++	+++	II
J. chinensis 'Stricta'	light green, needle-like	++	+++	+++	+++	+++	III
J. squamata 'Blue Star'	light blue, needle-like	+	++	+++	+++	+++	II
J.communis 'Repanda'	dark green, needle-like	+	+	++	++	++(+)	I
J.horizontalis 'Prince of Wales'	green-blue, needle-like	++	++	+++	+++	+++	III
J. virginiana 'Grey Owl'	greyish-green, combined	+	++	+++	+++	+++	II

Notes: "-" - no brown spots, "+" - slight browning "++" - browning 50% and higher, "+++" - browning 90% and higher.

ll the study species were differentiated into three groups of needle stability according to the degree of pheophytization: I (the most stable) – *J. communis'Repanda',J. sabina 'Cupressifolia'*; II (medium stable) – *J. squamata 'Blue Star', J.virginiana 'Grey Owl', J. chinensis 'Stricta', J.media 'Gold Star'*; III (low stable) – *J.conferta 'Schlager'* and *J. horizontalis 'Prince of Wales'*.

To obtain numerical results, a 5-point scale for assessing the damage to the surface was used in accordance with the following formula:

$$Ddt = (d_1 \times 1 + d_2 \times 2 + d_3 \times 3 + d_4 \times 4 + d_5 \times 5) / 5$$

Ddt – the score of damage to shoots by temperature; $d_1 \ldots d_5$ –damage score at a certain temperature of heating, 1…5 –coefficients of temperature influence – 40, 50, 60, 70, 80(Table 2)

Table 2

Degree of heat resistance of shrub species of juniper (according to F. M. Matskov)

Species	Coloration and type of needles	Temperature level, °C					Total damage score (Ddt)
		40	50	60	70	80	
		Damage score					
J.sabina 'Cupressifolia'	dark green, scaly	1	2	3	4	5	11.0
J.conferta 'Schlager'	light green, needle-like	3	3	4	4	5	13.4
J. media 'Gold Star'	golden-green, combined	3	4	4	5	5	10.0
J. chinensis 'Stricta'	light green, needle-like	2	3	4	4	5	12.2
J. squamata 'Blue Star'	light blue, needle-like	2	3	4	4	5	12.2
J.communis 'Repanda'	dark green, needle-like	1	1	2	3	4	8.2
J.horizontalis 'Prince of Wales'	green-blue, needle-like	3	4	4	5	5	13.6

J. virginiana 'Grey Owl'	greyish-green, combined	1	3	4	5	5	12.8

The ratio of the results obtained for the levels of heat resistance for each of the investigated species is given (Fig. 1)

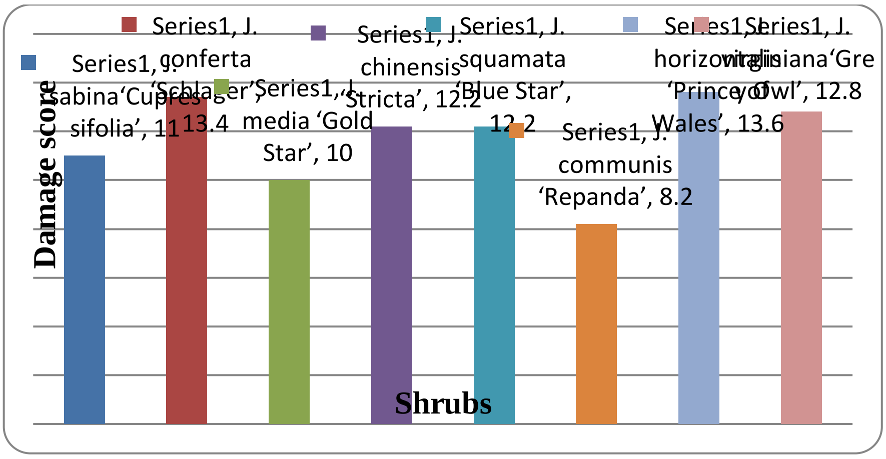

Fig. 1 - Ratio of heat resistance of juniper shrubs (points)

The level of heat resistance is correlated with the resistance of the needles to fading under the influence of high temperatures.As can be seen, the highest level of resistance to high temperatures have three cultivars – *J. communis 'Repanda'* - 8.2 (points), *J. media 'Gold Star'* - 10.0 (points), and *J. sabina 'Cupressifolia'* - 11.0 (points). The following cultivars – *J. chinensis 'Stricta'* - 12.2 (points), *J. squamata'Blue Star'* - 12.2 (points), and *J. virginiana 'Grey Owl'* - 12.8 (points) showed the medium heat resistance. The lowest levels of heat resistance and significant fading of the needle are characteristic of cultivars – *J. conferta 'Schlager'* - 13.4 (points) and *J.horizontalis 'Prince of Wales'* - 13.6 (points) [4].

In general, most of the study cultivars are characterized by high and medium resistance levels, which makes it possible to recommend them for wider use in urban greenery in the area exposed to high temperatures.

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FOREST FIRE IN UKRAINE (1990-2017)

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The fire danger in Ukraine is quite threatening, especially in recent years. This is due to the increase in average air temperature and long rainless periods. The increase in the burned area and number of fires, primarily in the south of the country, is due to the lack of state funding, and, consequently, the unsatisfactory organization of the work of the regional forest fire services. Some aspects of the country's forest fire danger were highlighted by A.D. Kuzyk [2]. Information about forest fires and losses from them for the period 1990-2017, obtained from statistical yearbooks is presented in table. 1 [1,3].

Table 1. Forest fires in Ukraine

Year	Burned area, ha	No. of fires, pcs.	Burned area of one fire, ha	Burned and damaged wood	
				of all, m^3	from 1 ha, m^3
1990	2388	2714	0,9	79236	33
1991	1717	2771	0,6	38051	22
1992	4101	5869	0,7	77758	19
1993	3178	2967	1,1	174354	55
1994	10040	7411	1,4	391159	39
1995	3537	3758	0,9	145400	41
1996	12671	4928	2,6	308543	24
1997	1467	2309	0,6	11806	8
1998	4418	3915	1,1	123034	28
1999	5532	6070	0,9	163858	30
2000	1610	3696	0,4	20249	13
2001	3772	3205	1,2	139604	37
2002	4983	6383	0,8	59206	12
2003	2817	4527	0,6	19720	7
2004	595	1876	0,3	1944	3
2005	2325	4223	0,6	32101	14
2006	4287	3842	1,1	53119	12
2007	13787	6100	2,3	1304271	95
2008	5529	4042	1,4	395257	71
2009	6315	7036	0,9	223764	35
2010	3668	3240	1,1	343840	94
2011	1049	2526	0,4	11804	11
2012	3479	2163	1,6	289291	83
2013	418	1113	0,4	2496	6
2014	13778	2003	6,9	144694	11
2015	14691	3813	3,9	170686	12
2016	1249	1249	1,0	32559	26
2017	5939	3131	1,9	149775	25
On average per year	4976	3817	1,3	175271	35

For the analyzed 28-year period, an average of almost 4,000 forest fires arose over an area of about 5,000 hectares a year. The area of one fire ranged from 0.3 (2004) to 6.9 (2014) ha. The large area of one fire indicates the low efficiency of forest fire services.

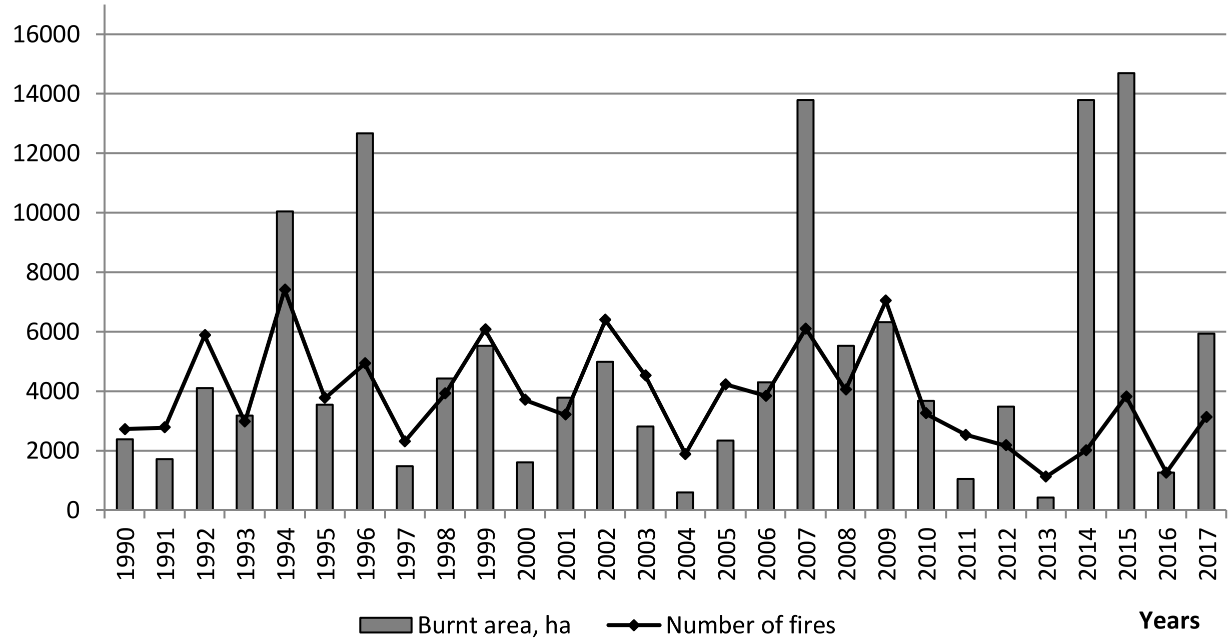

Fig. 1. Dynamics of the area and number of forest fires in Ukraine

In total, over the analyzed period, forest fires covered almost 140,000 ha of forest areas and 4.9 million cubic meters of wood was damaged and destroyed. The total burnt areas are practically equal to the area of forests larger than the area covered by forest vegetation for each region (ths. ha): Kherson (116.3), Zaporizhzhya (101.0) or Mykolayiv (89.2). The largest losses of wood amounted to 1.3 million m^3 as a result of fires that spread throughout Ukraine in 2007. A significant part of the fires was in the Kherson region.

The critical situation that has developed in Ukraine in the mentioned years arose under the influence of anthropogenic factors and weather conditions. Particularly in arid years, forest fires can cover large areas and cause enormous damage to the forestry industry and have a negative impact on the environment. Such circumstances emphasize the need to strengthen the protection of forests from fires.

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MODELING OF PINE STANDS FIRE AT YOUNG AGES

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The forest environment is a collection of plant origin materials, most of which are combustible depending on their physicochemical properties. Due to the scale of forest areas assessment, according to the degree of forest fires threat [1], coniferous stands, particularly, pine stands at a young age — up to 40 years old, are the most fire hazardous. In such plantations, brush fires almost always turn into crown fires, causing significant damage, and the elimination of such fires is difficult.

The fire hazard of forest stands depends on several indicators, one of which is the linear velocity of fire propagation [2]. Experimental studies on its determination with the use of annealing pose a risk of uncontrolled spread of fire; therefore, there is a need of bringing in firefighting equipment. In case of a real fire, first of all the main task is to eliminate it. It is not always possible to obtain sufficient information about the processes of fire spreading, but it is necessary to carry out a fire hazard assessment before it occurs. So that the computer simulation is an actual method for studying forest fires. Simulating the spread of a fire in the forest is complex, since many factors affect the combustion processes that must be considered in the model parameters. Currently, a significant number of forest fires diverse patterns are developed. Actual are the physical models, which are based on the equations of mathematical physics of heat and mass transfer processes in a fire. These models include the *Wildland-Urban Fire Dynamics Simulator(WFDS)* software [3], which is used in the research of forest fires.

The aim of the work is to assess the dependence of the fire danger of pine young stands from age according to the results of forest fire computer simulation. The fire was simulated for tree stands between 5 and 40 years old with a frequency of 5 years. In the process of growth, along with an increase in height, there is a decrease in the number of trees as a result of self-constriction, to simulate which was used a random number generator. Since the crowns between the rows are completed at the age of 10 years, causing almost complete disappearance of the grass cover, for sites at the age of 5 years, the ground combustible material was chosen for the grass cover, and starting from 10 years — a coniferous litter. The shape of the crowns of trees 5–15 years old was considered conical, and from the age of 20 a truncated cone. The trunk was considered a cone with a height equal to the height of the tree and a diameter at the ground level. Arson was carried out in three places. To determine the temperature of flame in simulating a fire in a *WFDS* environment, thermocouples were used, placing them in rows midway between the trees at a height of 0; 0.25; 0.5; 0.75 and 1 m from the soil surface. The maximum simulation time was set at 300 s. Other properties of combustible materials used for modeling were chosen in accordance with [3].

Wind speed is important for the spread of fire. In the process of modeling pine forest fires at wind speeds of up to 1 m/s, it was found out that the spread of flame by litter is very slow, therefore, the main studies were carried out for wind speeds of 2 m/s. During the simulation of the young pine stands fire, the moment of transition and the propagation speed of the brush and crown fire were determined. The propagation velocity was determined from the temperature values of the corresponding thermocouples.

The simulation process was observed in the program *Smokeview*. For example, Figure 1 shows the occurrence and spread of fire for young pine stands at the age of 10 years.

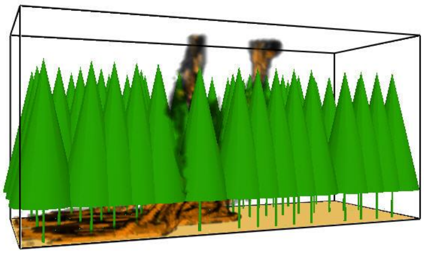

Figure 1 — Visualization of the process of modeling pine forest fires in age of 10 years on the experimental plot

According to the simulation results, obtained values of the average speed of fire propagation (Fig. 2).

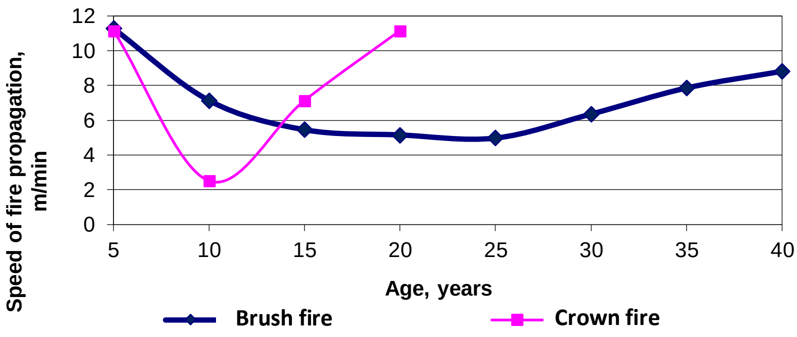

Figure 2 — The rate of spread of forest fire in the experimental plot

The general speed of fire propagation in pine young growths is shown in Fig. 2. In plantations at the age of 5 years, there was a continuous (brush and crown) fire. In particular, at the age of 10–15 years, a fire develops at a slower rate, which is explained by the absence of dry lower branches, which contribute to the spread of crown fire. For the presence of both forms of fire (total fire), the high rate of propagation of which is due to a significant stock of grass in a dry state and is more than 11 m/min. During the growing season, the moisture content of the grass was more than 100% and the spread of burning did not occur. At the age of 10–20 years, in the absence of grass, a brush fire and a crown fire occurred simultaneously, and the brush fire speed decreased with increasing age, and the overhead fire increased. At the age of 20-40 years, a crown-level fire does not occur, and the speed of propagation of a brush-wood fire increases with the planting age, which is explained by an increase in the stock of litter.

Conclusion. The most fire-dangerous are young pine trees under the age of 20 years, especially at the age of 15 and 20 years, in which the brush fire passes into the crown. In plantations older than 20 years, the risk is less, because there is only a brush fire.

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IMPACT OF COAL-MINING WASTE BURNING ON THE ENVIRONMENT

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Coal-mining waste burning causes a significant reduction in the environmental safety of a coal-mining region. In humans, due to exposure to toxic combustion products, various diseases of the respiratory organs and the cardiovascular system arise [1, 2]. There are cases of fire spreading from the coal mine dumps to the grassland vegetation, consequently causing conflagration forest fires. There was a case of colliery spoil tip explosion that resulted in human casualties.

Mining waste and coal-preparation waste contains about 1% of pyrite, the oxidation of which leads to the formation of sulfuric acid and readily soluble iron sulfates. As a result, sulfate waters accumulate at the foot of the coal mine dumps and spoil tips. Under the waste heaps, sulfuric acid is formed. It seeps into underground horizons and is spread by underground waters. (Fig. 1).

Fig. 1 - Sulfate waters at the foot of the dump of the coal-preparation plant of the *Lviv Coal Company* PJSC

One of the most promising ways to combat the environmental hazards of coal mine dumps is phytomelioration. On the mine dumps formed within the Small Polissya, the vegetation develops spontaneously [3-5].The most prominent representative of syngenetic succession is Scots pine (Fig. 2).

Fig. 2 - Natural colonization ofthe dump of the coal-preparation plant of theLviv *Coal Company* PJSC by Scots pine trees

According to the data [6], it is found that the SiO_2 and Al_2O_3 content in argillites and aleurolite is the highest. Total content (%) of toxic rock components is shown in the diagram in Fig. 3

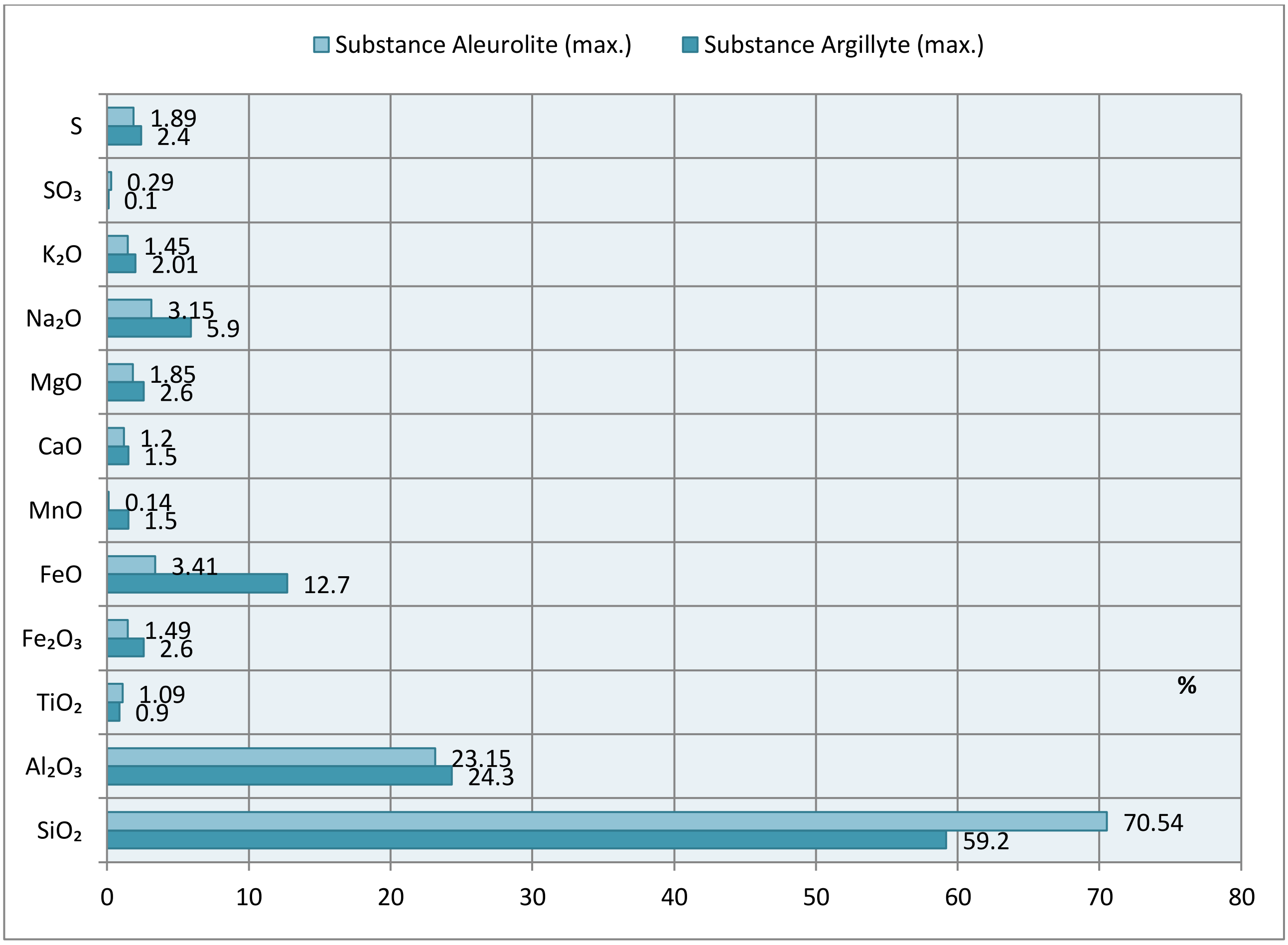

Fig. 3 - Chemical composition of the dump rocks of the coal-preparation plant of The *Lviv Coal Company* PJSC [6]

Thus, dumps of the coal industry cause the growth of the regional environmental hazards. To reduce the negative impact of coal mines on the environment, monitoring and environmental actions should be implemented.

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MOBILE FIRE FIGHTING EQUIPMENT DURING THE WILDFIRE SUPPRESSION

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The success of the extinguishing of fires in ecosystems, and in particular during the wildfires extiquishing depends on the available forces and means directly involved in the eradication of an emergency. For the successful extinguishing of a forest fire, it is necessary to attract a significant number of staff as well as the availability of modern high-quality mobile and productive equipment.

The main means of fire extinguishing to date remain water and aqueous solutions. From ensuring the uninterrupted supply of water over long distances and will depend on the success of forest fire suppression. Quite often, forest fires occur in areas where there are no sources of water supply, so rescue units need to apply a variety of tactical techniques to provide personnel with the required amount of water for extinguishing.

Modern technical means allow to provide water for long enough distances and in necessary volumes. For example, a modern pumping station (Fig. 1) can provide water flow in the amount from 7570 to 23 658 litres per minute [1].

Figure 1. Mobile Pumping Station

According to the tactics of extinguishing forest fires, one of the conditions is the creation of artificial barriers to prevent the spread of fire [2, 3]. The most widespread tactical method of stopping the spreading of lowland forest fires is the creation of mineralisation strip. In order to create such obstacles it possible to use any kind of improvised means or agricultural machinery. However, at first opportunity for these purposes, it is better to use special engineering machinery, for example, military obstacle-clearing vehicle (translation from Russian abbreviation "IMP") or a special fire tanks with similar capabilities (Fig. 2). The tactical and technical characteristics of the presented technical means allow to perform tasks more effectively and faster. Special attention should be paid to the obstacle-clearing vehicle since the existing manipulator also allows to eliminate the forest debris (logs, trees, etc.), which in turn can create opportunities for further passing of vehicles.

a) Obstacle-clearing vehicle

b) Special fire tank

Figure 2. Heavy vehicles for extinguishing wildfires

In spite of the considerable technical capabilities during forest fire extinguishing, it is often necessary to extinguish a fire involving air transport, in particular aeroplanes and helicopters.

Attracting air transport in the conditions of forest fire extinguishing gives a number of advantages, firstly, there is the possibility of water supply directly to the hotbed of fire in hard-to-reach places, and secondly, there is relatively no danger for staff. However, along with significant benefits, there is one significant drawback. For the successful delivery of an extinguishing agent in the firefighting area, it is necessary to carry it out as low as possible, since if the water will be fed too high to the ignition centre, practically nothing will reach the ground due to its evaporation in the atmosphere.

A sufficiently significant advantage today for the management of forest fire extinguishing activities may be the use of unmanned flying vehicles (quadcopter machines). The use of quadcopters allows to obtain in real time an image of carrying out operational actions on fire extinguishing and to analyse it, and according to the conducted analysis, the management may adjust its further actions. The main advantage of attracting quadcopters for the analysis of the situation is also the price of their use. If earlier for such analysis it was necessary to involve helicopters or aircraft, then for today it will be enough to spend some amount of time in order to practice in managing quadcopter and a relatively small amount of money for its purchase on the Internet.

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CONTENTS