ISSN 1821-1046
UDK 630

INSTITUTE OF FORESTRY
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INSTITUT ZA ŠUMARSTVO
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SUSTAINABLE FORESTRY ODRŽIVO ŠUMARSTVO

COLLECTION
TOM 67-68

ZBORNIK RADOVA
TOM 67-68

BELGRADE BEOGRAD
2013.

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Cover Page: Author of the Photos Tatjana Ćirković-Mitrović, M.Sc.
Naslovna strana: Autor fotografije mr Tatjana Ćirković-Mitrović

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

630

SUSTAINABLE Forestry : collection = Održivo šumarstvo = zbornik radova / chief
editor = glavni i odgovorni urednik Snežana
Rajković. - 2008, T. 57/58- . - Belgrade (Kneza Višeslava 3) : Institute of forestry, 2008- (Beograd : Black and White). - 24 cm

Godišnje. - Je nastavak: Zbornik radova - Institut za šumarstvo = ISSN 0354-1894
ISSN 1821-1046 = Sustainable Forestry
COBISS.SR-ID 157148172

CONTENT SADRŽAJ
TOM 67-68

INSTITUTE OF FORESTRY • BELGRADE
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SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 67-68, 2013 ZBORNIK RADOVA 67-68, 2013

UDK 630 181.43+630*436:630*231=111
Original scientific paper

CHANGES OF FOREST HABITATS DESTROYED BY FIRE AND THE RATE OF NATURAL REVITALISATION OF DAMAGED ECOSYSTEMS

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Abstract: *The paper examines the possibilities of natural regeneration of forest ecosystems destroyed by fire. The development of monitoring is presented in particular for black pine and beech forest sites, in which successive vegetation changes were analysed. The vegetation dynamics in presented localities was monitored immediately after the fire, a year, two years, three years, four years, five years and ten years after the fire. It has been established that the vegetation in a submontane beech forest site belongs to the Atropetum belladonnae association (Br.Bl.1930) - Tx.1931, Em, 1950. Four facies have been identified in the association. The post-fire natural regeneration of black pine depends on intensity of fire and the possibility for insemination of the area after the fire. The vegetation of fire sites on black pine forests' serpentine soil belongs to the Euphorbieto (cyparissias)-Brachypodietum pinnati association, and within it, four facies have been identified.*

Key words: fire, ecosystem, revitalisation, monitoring

ПРОМЕНЕ СТАНИШТА УНИШТЕНИХ ПОЖАРИМА И БРЗИНА ПРИРОДНЕ РЕВИТАЛИЗАЦИЈЕ ОШТЕЋЕНИХ ЕКОСИСТЕМА

Извод: *У раду су анализиране могућности природне ревитализације шумских екосистема уништених пожарима. Развој мониторинга посебно је приказан за станишта црног бора и букве, где су анализиране сукцесивне промене вегетације. Динамика вегетације на приказаним локалитетима је праћена непосредно после пожара, годину, две, три, четири, пет и десет година после пожара. Констатовано је да вегетација пожаришта на станишту брдске буковe шуме припада асоцијацији Atropetum belladonnae (Br.Bl.1930)-Tx.1931, Em, 1950. У асоцијацији је издвојено*

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четири фацијеса. Природно обнављање црнога бора после пожара зависи од јачине пожара и могућности осемењавања површине после пожара. Вегетација пожаришта на серпентинској подлози шума црнога бора припада асоцијацији Euphorbieto (cyparissias)-Brachypodietum pinnati, и у оквиру ње издвојена су два фацијеса.

Кључне речи: *пожар, екосистем, ревитализација, тониторинг.*

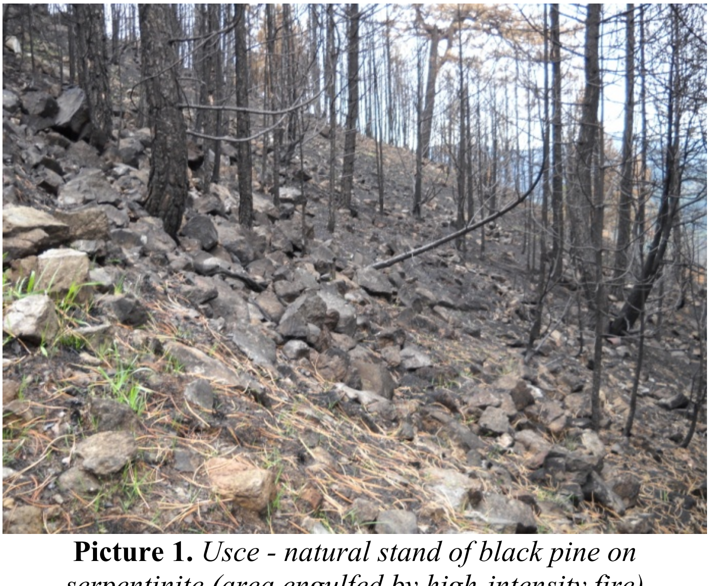
INTRODUCTION

Global warming is followed by increasingly intensified and prolonged forest fires in the northern parts of the planet, resulting in additional emission of carbon dioxide (CO_2) and acceleration of climatic changes. Ten years of monitoring led to the conclusion that during forest fires far more carbon dioxide gets emitted into the atmosphere than the forests have absorbed in the process of photosynthesis, which is a tendency that may only get worse in the future.

Even though most people see forest fires as burning trees, these fires are in fact fuelled mainly by dry grassy plants, shrubs, moss and organic materials in the soil.

One-half of the world's carbon reserves stays in the soil. This carbon, deposited over thousands of years, now gets into the air in the form of CO_2. The intensity and duration of fires in the northern regions are also impacted by ever-shorter snowy period of the year, altered plant composition, diminishing glaciers and the zone of eternally frozen land.

Over the last decade the area of fires has increased up to ten times, which is highly significant not only for climatic changes but also for the human health, as even the smallest particles of smoke may cause respiratory diseases. Moreover, the fires lead to release of harmful matters, including mercury, into the atmosphere.



Picture 1. *Usce - natural stand of black pine on serpentinite (area engulfed by high-intensity fire)*

The problem of global warming is one of the key ecological problems of the Earth. The scientists have linked global warming to numerous changes in the animal behavior and way of life, as well as in the development of plants (*Natura Geoscience*).

Fires cause major damage to the forests of Serbia every year. The occurrence, spread and duration of fires are influenced by numerous conditions, among which the most important are the presence of dry vegetative cover, its flammability and type of growth overlay. Organization of preventative measures though swift notification and extinction are crucial for reducing the occurrence and scope of forest fires, but once a fire breaks out, the size of direct damage and possible consequences depend on the speed of reaction and recovery of the forest site. Successful afforestation of burnt areas is particularly significant. Trees in areas affected by fire burn very quickly, resulting in disappearance of the original stands. Following the cleanup and recovery, it is necessary to carry out afforestation so as to create conditions for restoration of the natural balance into the original state. The presence of symbiotic fungi on the root of the replanted seedlings helps overcome the problems of afforestation, manifested through the inability of these plants to use micro and macro elements from the soil. The health condition of seedlings and cultures on burnt areas largely depends on the presence of biotic harmful factors, primarily phytophagous organisms. Following the completion of recovery and afforestation, young plants in newly erected cultures are higly vulnerable and their vitality is jeopardized given that the conditions of the environment, the soil in particular, substantially differ from those in the facilities for production of seedling materials. These facilities provided the plants with all conditions for normal and unobstructed development. With their vitality weakened, they now become susceptible to impact of multiple harmful factors existing in and around the forest-affected area. In order to avoid or reduce to a minimum the impact of the numerous harmful factors, it is essential to apply new and standard methods of substrate preparation based on the results of the analysis of all the required indicators.

With properly selected planting types and methods, protective measures and placement of fire protection strips, the positive effects of recovery become much more strongly assured. The application of biological methods through planting of mycorrhizal seedlings reduces the application of chemical agents for recovery of burnt areas and thus contributes to protection of soils and waters, i.e. to the protection of the environment.

Changes made to the forest ecosystem degraded by a forest fire may be properly assessed and investigated on the basis of measurable indicators. The standard assessment of damages presented through a market value of the burned trees does not comprise changes that may not be adequately expressed monetarily, but the consequences and duration of the period it takes the ecosystem to return to the original state reflect the enormity of the damage inflicted by the fire to the forest system. Indicators demonstrating the effects of fire on a forest ecosystem at the same time point to the direction of recovery of forest-affected areas. Indicators to be followed on the level of consequences of a fire may be classified into those related to the flora and fauna in the part above the ground, primarily linked to the health condition of the vegetation.

According to the reference sources, the effect of a fire on active and substitutional acidity of the soil is reflected in increased alkalinity. Ashes produced by burning of the organic matter of forest trees and shrubs, as well as herbaceous plants, contain high quantities of both alkaline and earth-alkaline elements.

The effect of a fire on earth organic matter may greatly vary depending on the type and intensity of a fire (high, low, etc.), the nature of burnt materials (wood, organic layover, dry grass), and type and humidity of the soil at the moment of fire. The effects of a fire on processes in the soil and their intensity may therefore be quite variable and cannot be generalized (Jose´ A. et al., 2004). No conclusions on generialized tendencies can be made for the majority of changes in the composition of humus caused by a fire. Strong fires (Almendros et al.,1990) cause formation of pyromorphic forms of humus, showing increased stability to chemical and biological degradation.

Burning of the organic matter leads to oxidation of organic carbon and its release into the atmosphere. This is turn destroys the organic cover. A part of the carbon from the organic cover is released into the atmosphere, while the remainder stays on the surface of the soil in the form of charred remnants. Carbon dust coming off the charred remnants of trees is also piled onto the ground surface. During a fire, the humus matter existing in the organo-mineral part of the soil are lost only in part, while the remaining (bigger) part is transformed into fractions that are more difficult to dissolve and break up. That means that in the group fraction composition of the humus, the ratio of brown humic acids drops whereas the ratio of humin is drastically increased.

Depending on the type of fire, type of soil and its properties (porosity, aeration and moisture at the moment of fire), as well as the quantity of charred organic remnants, the quantity of carbon in the soil surface layer may either increase or drop. Charred organic remnants of the organic cover and the living part of a forest ecosystem also form matter that is difficult to dissolve and resistant to bio-chemical degradation.

The ratio of organic carbon and nitrogen in the soil is an important indicator of the character of earth organic matter, the conditions for the acitivity of saprophytic microorganisms and release of nutrients from the humus. In the majority of cases the impact of fire reflects on the decrease in content of organic carbon in the soil. In certain cases, percentage of carbon content in the surface layer may increase due to accumulation of particles of charred parts of the burnt matter. The content of total nitrogen in the soil always drops after a fire (Neff et al. 2005). The decrease of total nitrogen is always greater than the decrease of carbon, which in all cases leads to extension of the ratio of carbon and nitrogen in the soil compared to the state prior to the fire.

As opposed to the organic forms of nitrogen, immediately after the fire the content of mineral nitrogen forms increases. At the same time, the content of both ammonia and nitrate nitrogen also goes up. Both of these nitrogen forms easily disappear from the soil. The ammonia form is susceptible to evaporation, particularly from neutral and alkaline pedo-chemical environments, while the nitrate is susceptible to rinsing by descendant flows outside of the physiologically active part of the solum.

Picture 2. *Svojbor (Novi Pazar) - area inflicted by strong fire*

After a fire, the change of content of easily accessible forms of phosphorus and potassium in the soil is more than other properties impacted by the character of burnt matter. Phosphorus and potassium represent macroelements of nutrition, existing in the organic form both in the living part of the ecosystem and in the organic cover. Unlike nitrogen, both these elements remain in the ashes, hence after a fire their content in the soil increases.

The concentration of phosphorus and potassium in the ashes produced as a consequence of a fire depends primarily on the type of burned matter, i.e. the species of trees or grass. Different types of plants have different needs for assimilating the phosphorus and potassium from the soil, which means that concentrations of these elements vary in different plants. Oligotrophic tree species, such as black pine or spruce, assimilate small quantities of these elements from the soil for their nutritional needs. The quantities of phosphorus and potassium in the soil are thus not large. Assimilation organs and meristematic tissues in all tree species have a significantly higher content of all plant assimilators compared to the bark and the trunk. Basophilic and neutrophilic herbaceous species may be especially rich in phosphorous and potassium content.

Improved methods of recovery and protection, as well as as advanced technological practices of field preparation and seeding, will enable better reception of seedlings, their survival and resistance to pathogens. The speed of natural revitalization of burnt areas may substantially decrease the costs of erecting new forests and restoring damaged econsystems.

Indicators related to the processes in the part of the ecosystem above the ground will be determined and used to records destruction and disappearance of certain species, succession of species and health condition of the surviving vegetation.

BIOLOGICAL MONITORING AS A PART OF THE MONITORING OF THE ENVIRONMENT

Biological monitoring is defined as a system of collecting, assessing and forecasting the changes in the environment caused by anthropogenic factors. The lead role in the system of biological monitoring belongs to ecosystem monitoring.

PRINCIPLES OF ECOSYSTEM MONITORING

Principles of monitoring the changes on sites destroyed in fires and speed of the natural revitalization of damaged ecosystems represent the commitment in the national environment protection policy and especially dynamics of strengthening the development of institutions specialized in monitoring of changes, securing their financial and human resources.

In general, these include the following:

- Rationalizing the system of monitoring the experimental areas, optimizing the ecosystems destroyed or damaged in fires, frequency of testing, automation of testing, selection of indicators and testing sites.
- Developing the monitoring with similar systems in the neighboring countries, harmonized with the EU countires, formulated and implemented in a joint testing program.
- Consistent monitoring of quantitative and qualitative site properties defined through quality control of the applied practices and standards measurements and observations.
- Reducing the list of indicators and frequency of their testing.
- Establishing and supporting the regional organizations for follow-up of ecosystem monitoring. The basic unit and organizational model is a territorial unit defined through climatic zones of vegetation in Serbia.
- Implementing the program tasks of the monitoring. Once all the set conditions have been met, it is delegated on equal terms to scientific institutions and NGOs that have adequate human resources for monitoring the required indicators.
- The strategic goal is that monitoring, in addition to fundamentals for protecting the needs of inhabitants, protection and control of water sources, gets the function of permanent surveillance over ecological changes in terms of protection of the ecological status and natural wealth.
- Active public participation in the information process and consolidation of the condition, causes and assessments of ecosystem revitalization.

Monitoring the ecosystems destroyed in fires and speed of natural revitalization

The plan and functioning of a monitoring program comprises numerous aspects, such as field measurements, sampling (collecting samples, preparation, storing methods and transport of samples), chemical analyses and data collection. All of these elements merit equal attention in the monitoring process. Planning of the monitoring program, selection of indicators of the degree of ecosystem damage, sites, testing frequency, field determination and measurement and laboratory analyses.

The basic rules for a successful monitoring program and ecosystem analysis are as follows:

1. Defined required information and monitoring program adjusted to the needs, rather than the other way round. It is assumed that the necessary financial resources and equipment have been secured.
2. Types and properties of the ecosystem must be considered in a comprehensive manner (through preliminary research, spatial and time changes separately).
3. Components for testing the condition of the ecosystem (biological indicators) must be defined.
4. Indicators, types of samples, testing frequency and sites must be carefully selected in compliance with the required information, instead of vice versa.
5. Mobile field equipment and lab devices should be selected in accordance with the specific nature of the required data, accuracy and sensitivity of selection, not the other way round.
6. Complete and operative review of data processing should be established.
7. Monitoring the ecosystem changes should be followed up through the relevant microclimatic measurements and analyses.
8. Quality of data should undergo regular internal and external control.
9. Data and findings should be provided to the decision-makers not only as tables with reviews of measured proportions but also as analyses, assessments and expert findings with relevant recommendations, solutions and measures of management.
10. The monitoring program should be periodically assessed from the standpoint of needs and experience, especially if carried out in areas with drastically changed site conditions compared to the natural state.

Monitoring program

The current monitoring in Serbia is not unified and is carried out on outdated equipment by insufficiently qualified personnel. Measurement programs are not fully compliant with the international standards. It is therefore necessary to integrate the monitoring system, staff training and relevant programs with the methods and standards of the European Union and normative acts of the expert groups within the ICPDR.

Monitoring should rely on systemic collection and assessment of data to explain what happens in ecosystems destroyed by fires and what is the speed of their natural revitalization. These indicators, as a whole, should be compared to the condition on the same undamaged ecosystems to show how quickly an ecosystem is revitalized and the direction taken during the recovery (which, given the climatic changes, need not gravitate toward the natural (currently existing) ecosystem).

One-sided approach to defining the biological responses, when analyzing distribution of organisms in view of a single factor (e.g. organic or inorganic matter, acidification, toxicants) is replaced by multivariant practices that analyse the dynamics of biocoenosis in view of several variables simultaneously.

The tendency to define a universal method of biomonitoring for large territories has been sidelined by the view that it is necessary to develop separate procedures for each area representing a natural biogeographic whole (eco-region) that will respect the individual features of each region. All procedures of biological monitoring should be based on the same principles, while the results must be comparable.

Unlike the methods that use physical or chemical parameters and mark the current conditions, biological methods of assessing the state of an ecosystem register long-term consequences. In addition to establishing the degree of damage to (destruction) of an ecosystem, the results of bio-monitoring enable determination of the capacity for natural revitalization.

Biomonitoring presented in this paper has rarely been used world-wide. It has mostly been criticized due to the length and cost of the process, lack of standardization of the techniques, complexity of data interpretation and variations in responses of organisms to the degrees of damage. Many of these criticisms have been overcome by placement of permanent sites in ecosystems that have been affected by fires of various intensities over different time periods.

Methods used in the biomonitoring are based on two fundamental principles:

- systems based on indicator organisms;
- structural and analytic principle (biological indexes and ecological methods) (Washington, H.G., 1984).

Each of these methods has its advantages and disadvantages, and therefore in different countries various approaches are used in research and practical work, depending on which method may be traditionally used or deemed the most suitable for the given environment. In the development of monitoring **"Changes of sites destroyed by fire and the rate of natural revitalization of damaged ecosystems",** given the long-term monitoring, elements of both principles were applied as this was seen as the only way to achieve the goals set in the Concept of Monitoring.

CONCEPT OF BIOMONITORING

The plan of organization of biomonitoring depends on the strategic goals. The goals are based on the following assumptions:

1. Establishing a regular biomonitoring system within the entire monitoring for following the condition of forests;
2. Defining efficient procedures, in accordance with the conditions in the field relevant for functioning of the national monitoring;
3. Relying on the existing, previously used procedures and their adjustment to the concrete conditions;
4. Ensuring the continuity of monitoring;
5. Defining an adaptable system of biological assessment.

The monitoring within **"Changes of sites destroyed by fire and the rate of natural revitalization of damaged ecosystems"** defines two phases:

Phase I

- Proposing procedures to make the biological monitoring operative.
- Define the activities for improvement, verification and application of procedures of assessing the ecological status of the area.

Phase II

- Defining the monitoring long-term.
- Defining the monitoring short-term.
- Basic framework of functioning of the monitoring, comprising:
  - Ratio between the monitoring component
  - Ratio between the national monitoring and other programs.
- Activities related to achievement of goals of previous points.
- Institution in charge of achieving the set tasks.
- Mechanisms, obligations and frameworks based on which the institution in charge would accomplish the task.
- Procedures to be improved and tested.
- Detailed time schedule of activities.

ELEMENTS OF BIOLOGICAL MONITORING

The following elements are included into the determination of the condition of ecosystems destroyed by fires and the rate of their revitalization:

- Herbaceous species, shrubs and woody species.

LOCATIONS OF TESTED BURNT AREAS AND CHARACTERISTICS OF FOREST SITES

Table 1 presents the basic data on sites from which samples were collected for monitoring of changes in ecosystems.

Table 1. *Basic data on sites*

Location	Coordinates	Exposition	Inclination (^{0})	Altitude (м)	Forest site
Usce 1	7464966 4814949	W	20	790	Black pine forest
Usce 2	7465019 4814882	W	7	808	Black pine forest
Usce 3	7464933 4814696	W	5	780	Black pine forest
Trstenik 1	7469367 4779350	S	2	925	Black pine forest
Trstenik 2	7469367 4779350	S	2	925	Black pine forest
Trstenik 3	7469367 4779350	S	2	925	Black pine forest
Lisa 1	7428582 4794844	S	20	1158	Black pine culture
Lisa 2	7428563 4794866	S	20	1158	Black pine culture
Lisa 3	7428821 4794783	SE	15	1158	Black pine culture
Goc 1	7475959 4836847	E	8	296	Black pine culture
Goc 2	7475959 4836847	W	10	288	Black pine culture
Goc 3	7475959 4836847	W	10	280	Black pine culture
Svojbor 1	7462254 4777581	W	24	603	Black pine culture
Svojbor 2	7462215 4777400	W	20	620	Black pine culture
Zavoj 5	7635794 4792680	SE	38	830	Beech forest
Vidlic 10	7641818 4780849	NE	8	1105	Beech forest
Vidlic 11	7641758 4780866	NE	6	1118	Beech forest
Vidlic 12	7641000 4678176	N	25	1113	Beech forest
Tupiznica 4	7586719 4838391	N	10	874	Beech forest
Radicevac 5	7613929 4826251	N	35	855	Beech forest
Markov kamen	7585910 4877380	N	25	630	Beech forest
Brezovica 1	7564855 4871958	N	35	860	Beech forest
Stol 1	7598004 4882186	N	25	303	Beech forest
Stol 2	7591621 4893660	NE	17	810	Beech forest
Stol 3	7591667 4893660	E	20	794	Beech forest
Stol 4	7591364 4894091	S	10	805	Beech forest

MONITORING OF SUCCESSIVE CHANGES IN VEGETATION

Dynamics of vegetation on the presented sites was monitored immediately after the fire, one, two, three, four, five and ten years after the fire. Within the scope of this paper data for beech forests and black pine forests will be presented.

BURNT AREA ON THE HABITAT OF BLACK PINE FOREST (*Pinus nigra* Arn.)

According to EUNIS classification, forests of black pine бора (Pinus nigra) (CODE G3.5) belong to pine forests of the Western Balkans (CODE G3.52).

Dynamics of the vegetation

Based on the analysis of the burnt area, the following were found to have the greatest degree of presence and coverage on the tested areas:

- In year one after the fire: *Moehringia trinervia, Rumex acetosella, Ajuga reptans, Vicia cracca,* etc.
- In year two after the fire: *Galium lucidum, Vicia cracca,Calamintha acinos, Alyssum murale, Potentilla opaca;*
- In year three after the fire: *Vicia cracca, Rumex acetosella, Senecio rupestris, Cirsium pannonicum, Viola tricolor, Ajuga reptans, Silene flavescens, Bromus squarosus, Sesleria rigida;*
- In year ten after the fire: *Vicia cracca, Verbascum nigrum, Euphorbia cyparissias, Brachypodium pinnatum, Erica carnea, Rubus tomentosus, Carex caryophyllea, Festuca gigantea* etc.

Regeneration of shrubs and woody species on burnt areas

Natural revitalization of the black pine after a fire depends on the strength of the fire and the possibility to inseminate the burnt area. A strong fire destroys not only the herbaceous cover but also the trunks on the site, thus making the revitalization impossible. Any seed that may have existed on the soil surface prior to the fire would also burn out. In a strong fire, the structure of the soil surface layers worsens and the soil becomes more compact, which makes natural regeneration of the burnt area even more difficult, but it creates conditions for quick propagation of species which in the absence of competing forest species “conquer” the area. This is the case with the facies *Potentilla opaca-Brachypodium pinnatum.*

In moderate ground fires the ground layer burns out and the seed directly reaches the soil, which may accelerate the natural regeneration. This situation is recognized by the facies defined as *Moehringia trinervia-Vicia cracca* and *Senecio rupestris-Vicia cracca.*

In the third year after a fire birch is well-regenerated and extensively present on the ten-year fire site. Trembling poplar and forest sallow are far less present. Among the shrubs, well-regenerated are the species *Genista* and *Cytisus*.

Vegetation of the burnt area on serpentine base of black pine forests belongs to the association *Euphorbieto (cyparissias)-Brachypodietum pinnati*.

The characteristic species of the association comprise 4 species, while the characteristic species of the class order and sub-order comprise 10. These species are among the best-developed on the burnt area and dictate its overall appearance.

The facies identified in the association are as follows:

1. Facies *Moehringia trinervia-Rumex acetosella* characterizes the first few years following a fire. It comprises therophyte plants, as well as those that have swift vegetative propagation.
2. Facies *Moehringia trinervia-Vicia cracca* is linked to two-year old burt areas. It is composed of therophyte plants of the family *Papilioniaceae*.

The above-named facies correspond to the phases of development of the association during individual years of age of a burnt area.

Picture 3. *Moehringia trinervia*

Picture 4. *Vicia cracca*

BURNT AREAS ON THE HABITAT OF BALKAN BEECH (FAGUS) FOREST

Under the EUNIS classification, Balkan beech forests (CODE G1.69) belong to beech (Fagus) forests (CODE G1.6).

Dynamics of the vegetation

- In the first year after a fire the most extensive coverage is by *Galium aparine,* then *Urtica dioica, Chrysanthemum parthenium, Galeopsis tetrahit, Rubus hirtus,* etc. Woody species have not been found.

- In the second year also *Galium aparine*, *Chrysanthemum parthenium,* then *Lathyrus pratensis, Galium mollugo* i *Rubus hirtus,* while among trees notable is the presence of vegetative shoots of hornbeam.
- In year five vegetative shoots of beech and trembling poplar are much more numerous, while among other species the most extensive coverage is by *Calamagrostis epigeios, Sambucus ebulus, Rubus hirtus, Epilobium angustifolium, Fragaria vesca,* etc.
- In year ten the presence of woody species is quite conspicuous. Beech has the largest degree of presence and coverage compared to other species. In this year *Populus tremula* is most extensively present. Other species are also numerous: *Rubus hirtus, Fragaria vesca, Calamagrostis epigeios, Circaea lutetiana, Epilobium angustifolium,* etc.
- Among woody species in year 25 afer a fire, beech is most extensively present, followed by trembling poplar. Among herbaceous species extensively present are *Rubus hirtus, Fragaria vesca, Circaea lutetiana, Epilobium montanum,* etc.

Vegetation of burt area on the habitat of mountain beech forest belongs to the association *Atropetum belladonnae (Br.Bl.1930) - Tx.1931, Em, 1950.*

There are four facies identified in the association:

1. Facies *Galium aparine*. The species *Galium aparine* develops the facies on a the burnt area of a mountain beech forest during the first years following a fire. This facies comprises fewer species than the others. The soil here has neutral reaction and is provided with potassium and phosphorus. It is rich in nitrogen, but the form of nitrogen is unsuitable for nutrition of the plants. Previous results on microbiological properties of the soil have shown that on a one-year burnt area the number of bacteria is increased, while the number of fungi and amonificators is reduced. Such a situation in the soil therefore does not favor development of many plants. During the first year after a fire there are no developed species from the family *Papilionaceae* on the burnt area, but they do appear as soon as year two.
2. Facies *Epilobium angustifolium*. Facies *Epilobium angustifolium* develops to an extensive degree on a burnt area of these forests a bit later on. It is most numerous around year five following a fire. At the same time other species develop on the burnt area, namely nitorphilous plants: *Calamagrostis epigeios, Sambucus ebulus, Rubus hirtus,* etc. Along with these plants pioneer tree species – trembling poplar and sallow – appear on the burnt area, while the edificator of the previous phytocenosis (*Fagus moesiaca)* has a rather extensive coverage. The soil is characterized by neutral reaction and particularly high quantity of nitrogen (1.08%).
3. Facies *Rubus hirtus-Fragaria vesca.* These two species virtually dominate the burnt area in the year ten after a fire. They are linked to many more types of burnt areas, even though their number is somewhat smaller compared to the

presence in the previously described facies. Pioneer tree species are well developed here. In the soil of this facies the number of bacteria and actinomycetes is somewhat reduced, while the overall number of fungi and amonificators is increased. According to its chemical and physical properties, the soil is similar to the conditions of forest unaffected by fire.

4. Facies *Populus tremula*. The coverage of trembling poplar in this facies surpasses the other species (with the exception of beech). In all likelihood its presence was even more extensive several years before, but it gradually dwindles in competition with the beech. The number of types of burnt areas is reduced, while the number of forest species is increased. In this facies the burt area is closest to the forest, according to both floristic composition and conditions of soil.

The above facies in the association at the same time represent phases in the progressive development of the association. Each phase characterizes a certain period of association development. The facies, i.e. phase *Populus tremula* is at the same time the final phase of the association and the final stadium of the development of vegetation until regeneration of the previous phytocenosis.

Association *Atropetum Belladonnae* is linked to burnt areas of *Fagion* on lower altitudes, on shadowy expositions with moist or fresh soil. The presence of *Atropa belladonna* is especially extensive in the first years after a fire. It grows in the places where the fire or another factor has opened the canopy and allowed more light to penetrate the cover and soil, thus making piling of organic matter and formation of humus impossible while enabling improvement of aearation conditions and therefore expediting the process of humification, i.e. mineralization of organic matter. That is why belladonna represents an indicator of soil conditions, primarily of wealth in plant assimilators.

CONCLUSION

Monitoring of successive changes on the habitat of black pine resulted in finding the following:

- In year one after the fire: *Moehringia trinervia, Rumex acetosella, Ajuga reptans, Vicia cracca,* etc.
- In year two after the fire: *Galium lucidum, Vicia cracca,Calamintha acinos, Alyssum murale, Potentilla opaca;*
- In year three after the fire: *Vicia cracca, Rumex acetosella, Senecio rupestris, Cirsium pannonicum, Viola tricolor, Ajuga reptans, Silene flavescens, Bromus squarosus, Sesleria rigida;*
- In year ten after the fire: *Vicia cracca, Verbascum nigrum, Euphorbia cyparissias, Brachypodium pinnatum, Erica carnea, Rubus tomentosus, Carex caryophyllea, Festuca gigantean,* etc.
- Natural revitalization of the black pine after a fire depends on the strength of the fire and the possibility to inseminate the burnt area. A strong fire destroys

not only the herbaceous cover but also the trunks on the site, thus making the revitalization impossible. Any seed that may have existed on the soil surface prior to the fire would also burn out. In a strong fire, the structure of the soil surface layers worsens and the soil becomes more compact, which makes natural regeneration of the burnt area even more difficult, but it creates conditions for quick propagation of species which in the absence of competing forest species "conquer" the area. This is the case with the facies *Potentilla opaca-Brachypodium pinnatum.*

In moderate ground fires the ground layer burns out and the seed directly reaches the soil, which may accelerate the natural regeneration. This situation is recognized by the facies defined as *Moehringia trinervia-Vicia cracca* and *Senecio rupestris-Vicia cracca.*

In the third year after a fire birch is well-regenerated and extensively present on the ten-year fire site. Trembling poplar and forest sallow are far less present. Among the shrubs, well-regenerated are the species *Genista* and *Cytisus*.

Vegetation of the burnt area on serpentine base of black pine forests belongs to the association *Euphorbieto (cyparissias)-Brachypodietum pinnati*.

The facies identified in the association are as follows:

1. Facies *Moehringia trinervia-Rumex acetosella*
2. Facies *Moehringia trinervia-Vicia cracca*

The above-named facies correspond to the phases of development of the association during individual years of age of a burnt area.

Monitoring of successive changes on the habitat of beech resulted in finding the following:

1. Facies *Galium aparine*
2. Facies *Epilobium angustifolium*
3. Facies *Rubus hirtus-Fragaria vesca*
4. Facies *Populus tremula*

The above facies in the association at the same time represent phases in the progressive development of the association. Each phase characterizes a certain period of association development. The facies, i.e. phase *Populus tremula* is at the same time the final phase of the association and the final stadium of the development of vegetation until regeneration of the previous phytocenosis.

Association *Atropetum Belladonnae* is linked to burnt areas of *Fagion* on lower altitudes, on shadowy expositions with moist or fresh soil. The presence of *Atropa belladonna* is especially extensive in the first years after a fire. It grows in the places where the fire or another factor has opened the canopy and allowed more light to penetrate the cover and soil, thus making piling of organic matter and formation of humus impossible while enabling improvement of aearation conditions and therefore expediting the process of humification, i.e. mineralization of organic matter. That is why belladonna represents an indicator of soil conditions, primarily of wealth in plant assimilators.

Acknowledgement:
This paper was realised as a part of the project "Studying climate change and its influence on the environment: impacts, adaptation and mitigation" (43007) financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research for the period 2011-2014.

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***Promene stanista unistenih pozarima i brzina prirodne revitalizacije ostecenih ekosistema (2012), Final Report, Institut za sumarstvo, Beograd.