UDK 630* 272 + 523
https://doi.org/10.31298/sl.146.5-6.7

Stručni članci – Professional papers
Šumarski list, 5–6 (2022): 255–261

THE HEALTH CONDITION OF TREES IN DENDROPARK AT FACULTY OF FORESTRY – SKOPJE WITH A SPECIAL FOCUS ON FUNGAL DISEASES AND INSECT PESTS

ZDRAVSTVENO STANJE DRVEĆA U DENDROPARKU ŠUMARSKOG FAKULTETA – SKOPLJE SA POSEBNIM OSVRTOM NA GLJIVIČNE BOLESTI I ŠTETNE KUKCE

Irena PAPAZOVA-ANAKIEVA[1], Sterja NAČESKI[2], Margarita GEORGIEVA[3]

SUMMARY

The Dendropark at the Faculty of Forestry in Skopje, North Macedonia, was established as an 'outdoor museum' with a collection of forest trees and shrub vegetation. The collection was planted in 1950 on the area of 4.05 ha, and includes 336 taxa from native Macedonian and Balkan endemic dendroflora and introduced species from around the world. The Dendropark, like the other botanical gardens all over the world, offers a unique resource that facilitate earlier detection of the potential invasive threats to forest tree species. The inventoried population includes 444 trees belonging to 43 families. The three most represented families are *Pinaceae* with 21 species (19.4% of the inventoried plants), *Cupressaceae* with 16 species (15.8%) and *Rosaceae* with 18 species (7.4%). The 2014 survey indicated that 33.8% of the total number of trees were rated with good health status, 1.8% as very good, 31.1% rated as fair, while 24.5% were poor. Approximately 4.1% were rated to be in a critical state (in a state of decline), and 4.7% of trees were dead. The assessment of health status of plants in the Dendropark could be used as a valuable asset to planners and decision makers and provides information about the quality, quantity and location of natural resources in urban areas. Identifying changes in plant species composition and presence of invasive pests and diseases helps maintaining healthy urban forests.

KEY WORDS: *Platanus orientalis* L., powdery mildews, bark beetles

INTRODUCTION
UVOD

Acad. Hans Em founded the Dendropark at the Faculty of Forestry in Skopje, North Macedonia, as an 'outdoor museum' of living collection of forest trees and shrubs (Em et al., 1968). The collection was built in 1950 on the area of 4.05 ha, and includes 336 taxa from native Macedonian and Balkan endemic dendroflora and introduced species from around the world. The most predominant tree species originated from East Asia (China, Japan, Korea) and the Himalayas (30%) followed by the group from South Europe,

[1] Prof. Irena Papazova-Anakieva, Ph.D. Ss. Cyril and Methodius University in Skopje, Hans Em Faculty of Forest Sciences, Landscape Architecture and Environmental Engineering, 16 Makedonska Brigada No.1, 1000 Skopje, North Macedonia *corresponding author, e-mail:ipapazova@sf.ukim.edu.mk
[2] Prof. Sterja Načeski, Ph.D. Ss. Cyril and Methodius University in Skopje, Hans Em Faculty of Forest Sciences, Landscape Architecture and Environmental Engineering, 16 Makedonska Brigada No.1, 1000 Skopje, North Macedonia, e-mail: snaceski@sf.ukim.edu.mk
[3] Prof. Margarita Georgieva, PhD. Bulgarian Academy of Sciences, Forest Research Institute,132 "St. Kliment Ohridski" Blvd.1756 Sofia, Bulgaria, e-mail:margaritageorgiev@gmail.com

the Mediterranean and North Africa (20%). On the third and fourth place (with 15%) were the groups from Europe and Euro-Asia as well as those originating from North America; the fifth place (12.5%) belonged to the group of East European, Caucasian, Minor-Asiatic and Near-Asiatic types; then came the types from the paleotropic and neotropic areas in Australia (5%). Finally, there were types from areas which were not mentioned above and which made 2.5% of the total number of the plants in the collection.

The principal purpose of the Dendropark was to serve as a teaching, research and display green area. In fact, this park has been used as an open 'classroom' in nature where the ecological influences and the interaction of the dendroflora and the environment have been investigated. Resistance to winter frost and summer drought, growth and development, blooming and fruitfulness, generative and vegetative reproduction within the collection, damages by insect pests and plant pathogens were studied (Em et al., 1968). Through its location, nature and mission, this small forest area is ideally suited to serve as an example of a special kind of urban green area. Urban forests undoubtedly bring many benefits: enhancing the urban landscape, increasing people's feelings of well-being (Kaplan and Kaplan, 1989; Kuo, 2001; 2003), reducing crime (Kuo and Sullivan, 2001) and providing a multitude of ecosystem services (McPherson et al., 1994; Costanza et al., 1997). The latter includes reductions in levels of airborne particulates and other pollutants (Nowak, 1994; Freer-Smith et al., 2004; Nowak et al., 2006; Escobedo et al., 2008), diminishing so-called 'Heat Island' effects (Heisler et al., 1994; Deak Sjöman et al., 2015) reduced levels of energy consumption (McPherson, 1994) and alleviation of flooding events (Bolund, Hunhammar, 1999).

Because the urban green area is a dynamic matrix of biological, physical and social resources, data collection should be comprehensive and continuous to accurately reflect the complex interactions among its resource components. Comparisons of repeated inventories may be used to monitor forest health and could prevent future catastrophic damages of urban greenery.

Considering that the last inventory was done in 1967 (Em et al., 1968), and that since then the Dendropark has suffered changes in its green area, conducting a tree inventory was essential to review the current state and presence of insect pests and fungal disease. The purpose of the current study was to assess the health condition of present tree species and to indicate ones that were potentially hazardous and require removal.

MATERIALS AND METHODS
MATERIJALI I METODE

The inventory was conducted in the Dendropark between March 2013 and October 2014, throughout the growing seasons. All trees were individually inventoried, assessed and recorded as described below:

- location - all trees were georeferenced and the number has been assigned to each tree (chronologically) during the data collection process;
- identification - botanical name identifies each tree (plant labels)
- health condition - the vigour and health condition of each tree was recorded as one of the following categories adapted from the rating system established by the International Society of Arboriculture® (ISA):

– Excellent- 100%-90% condition class. The tree is nearly perfect in condition, vigor and form. This rarely used category is generally applicable to small DBH trees or shrubs that have been recently transplanted and are well established. It also applies to large trees that have established themselves successfully in the landscape.

– Very Good -89%-80% condition class. Overall, the tree is healthy and satisfactory in condition, vigor, and form. The tree has no major structural problems, no mechanical damage, and may only have insignificant aesthetic, insect, disease, or structure problems.

– Good -79%-61% condition class. The tree has no major structural problems, no significant mechanical damage, may have only minor aesthetic insect, disease, or structure problems, yet is in good health.

– Fair -60%-41% condition class. The tree may exhibit the following characteristics: minor structural problems and/or mechanical damage, significant damage from non-fatal or disfiguring diseases, minor crown imbalance or thin crown, or stunted growth compared to adjacent trees or shrubs. This condition can also include trees that have been topped, but show reasonable vitality and show no obvious signs of decay.

– Poor -40%-21% condition class. The tree appears unhealthy and may have structural defects such as codominant stems, severe included bark, or severe trunk and/or limb decay. A tree in this category may also have severe mechanical damage, crown dieback, or poor vigor threatening its ability to thrive. Trees in poor condition may respond to appropriate maintenance procedures, although these procedures may be cost-prohibitive to undertake.

– Critical -20%-1% condition class. The tree has a major structural problem that presents an unacceptable risk, has very little vigor, and/or has an insect or disease problem that is fatal and, if not corrected, may threaten other trees on the property.

– Dead -0% condition class. This category refers to dead trees only.

Trees were surveyed for the presence of symptoms and signs of diseases on the base of a visual observation. Samples

from infected trees were placed in specially prepared paper boxes and brought to the laboratory for microscopic identification. Traditional methods for entomological and phytopathological identification were used. Additional isolation of the fungal pathogens in suitable standard agar media and studying the cultural characteristics such as colony morphology, colour and production of asexual structures, were carried-out. Slide mounts of specimens were prepared for observation using microscope (NIKON, ECLIPSE, E400) in order to confirm fungal identification. Morphological characteristics of spores were the major means of identification using several taxonomic keys (Barnett and Hunter, 1972; Sutton, 1980; Sinclair, 2005).

Inspection covered all plant parts and any existing insect stage(s) or infestation symptoms were identified on-site if possible. In case of uncertainty, samples of the occurring insects in different stage(s) were transferred in suitable containers to the laboratory for identification using several taxonomic keys (Johnson and Lyon, 1991; Mihajlović, 2008). Data from the completed tree inventory was transferred to Microsoft Excel for data summarization. Also, for each tree species both the distribution and the entire classification were included (Phylum, Class, Order, Family).

RESULTS
REZULTATI

The inventoried population included 444 trees belonging to 43 families. The three most represented families were *Pinaceae* with 21 species (86 trees, 19.4% of the inventoried population), followed by *Cupressaceae* with 16 species (70 trees, 15.8%), and *Rosaceae* with 18 species (33 trees, 7.4%). The most dominant genus by the number of species within Dendropark was *Acer* with 7 species followed by *Pinus* and *Quercus* with 6 species, and *Abies*, *Juniperus* and *Picea* with 5 species by genus. The most numerous species was *Platanus orientalis* L. with 22 trees.

The health condition of each tree was recorded according to the categories adapted from the rating system established by the International Society of Arboriculture® (ISA).

In the excellent condition class no tree was assessed. Only 1.8% of the population were rated in very good condition, belonging to family *Ginkgoaceae* (*Ginkgo biloba* L.), *Pinaceae* (*Cedrus atlantica* (Endl.) Manetti ex Carriere, *Abies alba* Mill.), *Rosaceae* (*Prunus serrulata* Lindl.), *Oleaceae* (*Forsythia europaea* Degen & Bald) and *Berberidaceae* (*Berberis julianiae* Schneid.). Trees in this category looked healthy and satisfactory in condition, vigour, and form. The trees had no major structural problems, but had insignificant aesthetic problems.

In the good condition class one hundred and fifty trees (33.8%) were rated and over half of these trees had structural defects or codominant stems. Other common issues included powdery mildews, aphids and mechanical damage. In this category, the most represented were trees from the family *Platanaceae* (21 individuals), *Pinaceae* (18) and *Cupressaceae* (15) family. The fungal pathogens causing powdery mildew were registered on leaves of trees from genera *Quercus, Berberis* and *Acer*: *Microsphaera alphitoides* Griffon & Maubl., *M. berberidicola* F.L. Tai and *Uncinula aceris* (DC.) Sacc. Symptoms of necrotic leaf spots caused by *Mycosphaerella mori* (Fuckel) F.A.Wolf were observed on mulberry plants (*Morus alba* L.) and leaf spots caused by *Septoria alni* Sacc. on *Alnus* sp.

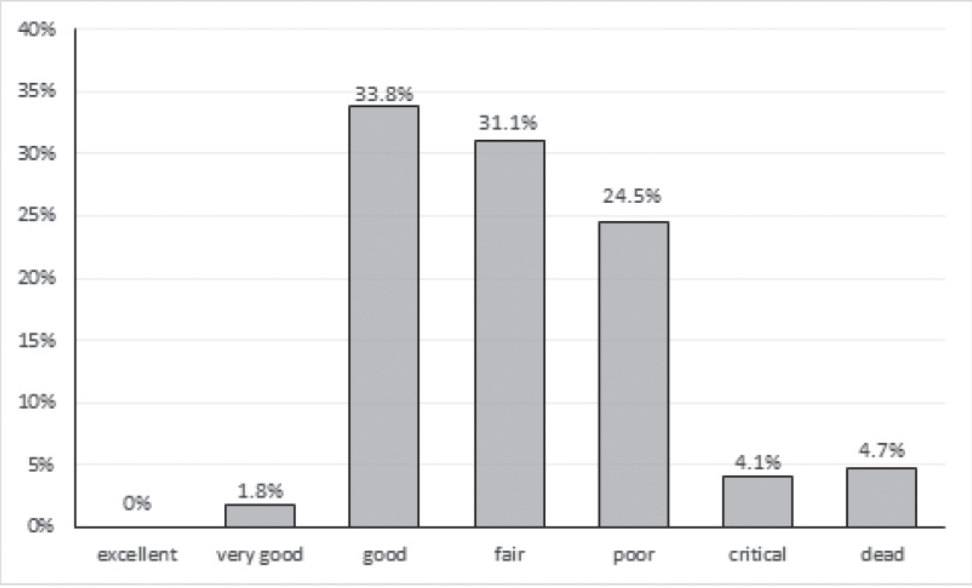

Figure 1. Rating of trees according to their health condition in the Denropark of Faculty of Forestry, Skopje
Slika 1. Ocjena drveća prema njihovom zdravstvenom stanju u Denroparku Šumarskog fakulteta u Skoplju

Symptoms and some stages of the insects of the European oak leaf roller, *Tortrix viridana* L. (*Lepidoptera*: *Tortricidae*) and *Operophtera brumata* L. (*Lepidoptera*: *Geometridae*) were found within the crowns of attacked trees on *Quercus robur* L. Plane leaf miner *Phyllonorycter platani* Stgr. (*Lepidoptera*: *Gracillariidae*) was a widely distributed insect species on *Platanus orientalis* L..

On the conifers, more precisely on the *Cupressus arizonica* Greene, *Buprestis cupressi* Germ. (*Coleoptera*: *Buprestidae*) was registered and on *Abies nordmanniana* (Steven) Spach two species were registered *Sacchiphantes viridis* Ratz. and *Sacchiphantes abietis* L. (*Hemiptera*: *Adelgidae).*

One hundred and thirty eight trees (31.1%), were rated as fair. In this class the most prevalent family was *Pinaceae* both in species diversity and number of individuals. Bark beetles (*Coleoptera*: *Curculionidae*) *Ips sexdentatus* Börner, and *I. acuminatus* Gyll., were established on *Pinus peuce* Griseb. and *P. brutia* Ten. *Physokermes piceae* Schrank, was detected on *Pinus pungens*.

In this class fungal pathogens from *Ascomycota* were registered, three of them caused powdery mildews, *Phyllactinia guttata* (Wallr.) Lév. on *Pistacia terebinthus* L., *P. corylea* (Pers.) P. Karst. on *Corylus avellana* L. and *M. alphitoides* Griffon & Maubl. on *Quercus cerris* L.. The other three identified species were *Guignardia aesculi* (Peck) V.B. Stewart causing leaf necrosis on *Aesculus hippocastanum* L. and *M. mori* on *Morus alba* L. and *S. alni* on *Alnus subcordata* C.A.Mey. causing leaf spots. The rust *Gymnosporangium sabinae* (Dicks.) G. Winter, which is an obligate parasite, was detected on *Juniperus excelsa* M. Bieb. Two species of white–rot fungi were determined on trees of fair health status, *Coriolus hirsutus* (Wulfen) Pat. (*Polyporales:Polyporaceae*) on *Magnolia soulangeana* Soul.-Bod and *Schizophyllum commune* Fr. (*Agaricales*: *Schizophyllaceae*) on *Catalpa bignonioides* Walt.

Among the found insect pests, the most numerous were *Cameraria ohridella* Deschka & Dimić on *Aesculus hippocastanum* L. and *P. platani* on *Platanus orientalis* L., and also *Buprestis cupressi* Germar (*Coleoptera*: *Buprestidae*) which caused serious damages to *Cupressus arizonica*.

The health status of 109 trees (24.5%) was rated as poor. As in the previous class, the most prevalent complex of damaged trees in this category was from family *Pinaceae*. Three fungal pathogens were registered - *Lophodermium piceae* (Fuckel) Höhn. on *Picea pungens* Engelm. and *Lirula nervisequia* var. *nervisequia* (DC.) Darker on *Abies concolor* (Gordon) Lindl. ex Hildebr and *Cyclaneusma niveum* (Pers.) DiCosmo causing needle cast disease on *Pinus brutia* Ten.

On the deciduous trees from this category four powdery mildews were recorded: *Phyllactinia corylea* (Pers.) P. Karst. on *Corylus avellana* L., *Uncinula aceris* (DC.) Sacc. on *Acer negundo* L., *U. salicis* (DC.) G. Winter on *Salix matsudana* Koidzumi and *U. fraxini* Miyabe on *Fraxinus sp*.. The other two identified species were from the family *Botryosphaeriaceae*, *Guignardia aesculi* (Peck) V.B. Stewart causing leaf necrosis on *A. hippocastanum* L. and *Phyllosticta magnoliae* Sacc causing leaf spots on *Magnolia soulangeana* Soul.-Bod.. From the Phylum *Basidiomycota* one obligate parasite, rust *Gymnosporangium sabinae* (Dicks.) G. Winter was determined on *J. excelsa* M. Bieb. and one saprobic white–rot fungus *Ganoderma applanatum* (Pers.) Pat. (*Polyporales*: *Ganodermatacea*).

In this category, the most encountered insect pest was *C. ohridella* on *Aesculus hippocastanum* L.. *Thaumetopoea processionea* L. was established on *Pistacia terebintus* L. and *Operophtera brumata* L. on oak. Four bark beetles *I. sexdentatus* and *I. acuminatus* Gyll., *Pityogenes bidentatus* (Herb.) and *P. quadridens* (Hart.) were detected on *Pinus brutia* trees. From Order *Hemiptera* only one species *Physokermes piceae* Schrank, and one from order *Coleoptera, Buprestis cupressi* Germar.

Eighteen trees (4.1%) were in a critical condition. Most of them belonged to families *Cupressaceae* (*J. virginiana* L., *Thuja occidentalis* L.) and *Pinaceae - Abies alba* Mill., *Pinus peuce* Griseb, *P. excelsa* (Lam.) Link.). The fungus *Nectria galligena* Bres. caused irregular swellings which cracked open and exposed areas of the wood on stems of *Betula pendula*. Phomopsis blight disease caused by *Phomopsis juniperivora* Hahn. was detected on *Thuja occidentalis* L. and *Gymnosporangium sabinae* (Dicks.) Winter on *Juniperus excelsa* M.-Bieb..

Twenty-one dead trees were counted in the park. The bark beetles *Ips sexdentatus* Börner and *I. acuminatus* Gyll. were registered on them. The deterioration process occurred with different intensity.

DISCUSSION
RASPRAVA

The benefits provided by healthy and well-managed urban forests are extensively documented and far-reaching. The value of these contributions are posed to increase in the future, but at the same time, mounting threats from insects, diseases, invasive species, climate change and changing infrastructure could limit the contributions. Due to elevated temperatures (urban heat island effect), restricted rooting space, impervious surfaces and poor growth medium, urban trees in particular suffer from lack of water and oxygen, as well as imbalanced provision of nutrients (Craul, 1999; Hoff, 2001; Sieghardt et al., 2005; Roloff et al., 2009). Climate change-induced elevation of temperatures combined with longer periods of drought during the growing season would impose further stresses on urban trees (IPCC, 2007; Gill et

al., 2007). This stress was often found to increase susceptibility to insect pests (Foggo et al., 1994; Koricheva et al., 1998), while evidence is more limited, or at least variable, when it comes to pathogens (Tubby and Webber, 2010). Canker/dieback pathogens are more likely to be positively associated with host stress, particularly drought stress, than some foliar pathogens (Diminić and Hrašovec, 2005, Desprez-Loustau et al., 2006). Therefore, the urban environment is hostile to the long-term health of trees and shrubs and early detection of emerging threats is vital. Conducting a tree inventory is often the first step. In recent decades there has been an increased interest in urban tree inventories, resulting from growing problems with pest and pathogen attack on the urban tree stock (Raupp et al. 2006) and growing awareness of the multiple ecosystem services which trees provide in the cityscape among the decision-makers (Hubacek and Kronenberg, 2013; Georgiev et al., 2017).

The comparison of this inventory with the inventory made in the 1967 (Em et al., 1968) demonstrated that 223 species are currently absent from the Dendropark. The number of the species of the three most represented families *Pinaceae* (21), *Cupressaceae* (16), and *Rosaceae* (18) encountered in 1967 inventory were 30, 15 and 51 respectively.

As previously mentioned, since the last inventory in 1967 (Em et al.,1968), the collective Dendropark around Faculty of Forestry building has suffered changes in its surface and its contents, caused by the construction of a several buildings on the site which had previously been occupied by the Dendropark. This is one of the main reasons for such a drastic reduction in the number of the species.

Comparisons of repeated inventories may be used to monitor the health status of urban trees, but in current study, the lack of information regarding the physical position of the trees in the inventory from 1967, was especially problematic circumstance with the extremely long period of almost fifty years between the two inventories. This period corresponds to the average lifespan of the most species from the *Rosaceae* family whose number was evidently reduced (from 51 species in 1967 to 18 species in 2014).

The importance of the monitoring and regular pest and disease surveys became clear when the invasive box tree moth, *Cydalima perspectalis* (Walker) was established in the Dendropark in 2015, the following year after the inventory was completed. This was another evidence that living plant collections at botanical gardens and arboreta around the world can serve as early warning systems to help predict and prevent the invasion of new pests (insects, pathogens, or plants) (Britton et al., 2010). In many ways, urban greenspace represents an extended form of 'Sentinel Planting' (Fagan et al., 2008) where many organisms with the capacity to devastate sections of our environment will be most likely to have a visible impact and therefore be picked up during the initial stages of establishment (Tubby and Webber, 2010). This is highly significant as early detection offers the only realistic prospect of eradication of pioneer populations (Tubby and Webber, 2010).

The 2014 survey indicated that 33.8% of the total number of the trees were rated as good, 1.8% as very good, 31.1% as fair, while 24.5% were poor. Approximately 4.1% were rated to be in a critical state (in a state of decline), and 4.7% of trees were dead (Figure 1).

The total number of pest records was 128, 59 for insects belonging to 9 families and 69 for pathogens belonging to 15 families. The most prevalent family was *Erysiphaceae* both in species diversity (7) and number of individual pathogen records (16). This also is not surprising given that the powdery mildews are some of the world's most frequently encountered plant pathogenic fungi (Glawe, 2008).

Species belonging to the family *Curculionidae*, more precisely the bark beetles (*Ips sexdentatus* Börner, *I. acuminatus* Gyll., *Pityogenes bidentatus* (Herb.) and *P. quadridens* (Hart.)) were with the highest number of records among pest insects. Therefore it was not unexpected that in the poorest conditions were the species from the family *Pinaceae* from which 41.9% of all individuals were rated as poor.

Of the most commonly found tree species, the healthiest was *Platanus orientalis* L. with 22 trees of which 21 were rated as good and only one as fair. *Apiognomonia veneta* (Sacc. & Speg.) Höhn. was not present nor any wood-decaying fungi, only the plane leaf miner, *Phyllonorycter platani* Stgr. was recorded on almost all examined trees but with very low populations.

The data that have been collected and analyzed to develop this inventory contribute significant information about the tree population and can be utilized to guide the proactive management of that resource. Tree inventory data can be utilized to justify needed priority and proactive tree maintenance activities as well as tree planting and preservation initiatives.

This inventory could also be used as an educational tool, in public relations, to educate residents about the benefits of a healthy, well-managed urban forest, and to inform them about species best suited to the community.

CONCLUSION
ZAKLJUČAK

Urban forests provide a multitude of benefits to the society. To maximize these benefits an urban forest inventory is often needed for planning and management purposes. Urban forest inventories are a valuable asset to planners and decision makers and can provide needed information about the quality, quantity and location of natural resources in urban

areas. Identifying changes in plant species composition cover types, and presence of pest and pathogens will provide insight to maintain healthy urban forests.

With this inventory as an essential monitoring tool, the Dendropark like the other botanical gardens all over the world, offer a unique resource to help detect potential invasive threats to forest health. In this way, it could be a valuable contribution to the International Sentinel Plant Network (ISPN).

REFERENCES
LITERATURA

- Barnett, H.L., Hunter, B.B. 1972. Illustrated Genera of Fungi Imperfecti. 3rd ed., Burgess Publishing, Minnesota, USA.
- Bolund, P., Hunhammar, S. 1999. Ecosystem services in urban areas. Ecol. Econ. 29, 293-301.
- Britton, K.O., White, P., Kramer, A., Hudler, G., 2010. A new approach to stopping the spread of invasive insects and pathogens: early detection and rapid response via a global network of sentinel plantings. New Zealand Journal of Forestry Science 40, 109-114.
- Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M. and Hannon, B. 1997. The value of the world's ecosystems and natural capital. Nature. 387, 253-260.
- Craul, P.J. 1999. Urban Soil – Applications and Practices. John Wiley & Sons, Canada.
- Deak Sjöman, J., Hirons, A., Sjöman, H., 2015. Branch area index of solitaire trees—its use for designing with regulating ecosystem services. J. Environ.Qual., Vol. 45 No. 1, p. 175-187
- Desprez-Loustau, M.L., Marçais, B., Nageleisen, L.-M., Piou, D., Vannini, A. 2006 Interactive effects of drought and pathogens in forest trees. Ann. For. Sci. 63, 597-612.
- Diminić D., Hrašovec, B., 2005. Uloga bolesti i *štetnika* pri odabiru drveća u krajobraznoj arhitekturi. Agronomski glasnik, 2-4/2005: 311.
- Em, H., Dzekov, S., Andonovski, A.1968. Kolekcionen arboretum in Dendropark.UKIM, 83pp.
- Escobedo, F.J., Wager, J.E., Nowak, D.J., Luz de la Maza, C., Rodriguez, M., Crane, D.E. 2008. Analysing the cost effectiveness of Santiago, Chile's policy of using urban forests to improve air quality. J. Environ. Manage. 86, 148–157.
- Fagan, L., Bithell, S., Dick, M. 2008. Systems for identifying invasive threats to New Zealand flora by using overseas plantings of New Zealand plants. In Surveillance for Biosecurity: Preborder Pest Management. K.J. Fourd, A.I. Popay and S.M. Zydenbos (eds). New Zealand Plant Protection Society, Hastings, New Zealand, 51-62.
- Foggo, A., Speight, M.R. and Grégoire, J.C. 1994. Root disturbance of common ash, *Fraxinus excelsior* (Oleaceae), leads to reduced foliar toughness and increased feeding by a folivorous weevil, *Stereonychus fraxini* (Coleoptera, Curculionidae). Ecol. Entomol 19, 344-348.
- Freer-Smith, P.H., El-Khatib, A.A., Taylor, G. 2004. Capture of particulate pollution by trees: a comparison of species typical of semi-arid areas (*Ficus nitida* and *Eucalyptus globulus*) within European and North American species. Water Air Soil Pollut. 155, 173-187.
- Georgiev, G., M. Georgieva, P. Mirchev, M. Zhiyanski. 2017. Main insect pests and fungal pathogens on tree and shrub vegetation in urban ecosystems. Kitanova S. (Ed.). Hlorind Ltd., Sofia, 54 pp. ISBN 978-619-7228-04-5.
- Gill, S.E., Handley, J.F., Ennos, A.R., Pauleit, S. 2007. Adapting cities for climate change: the role of the green infrastructure. Built Environment 33 (1) 115-133.
- Glawe DA, 2008. The powdery mildews: a review of the world's most familiar (yet poorly known) plant pathogens. Annual Review of Phytopathology 46, 27–51.
- Heisler, G.M., Grimmon, S., Grant, R.H., Souch, C. 1994. Investigation of the influence of Chicago's urban forests on wind and air temperature within residential neighbourhoods. In Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. General Technical Report NE-186. E.G. McPherson, D.J. Nowak and R.A. Rowntree (eds). U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Radnor, PA, pp. 19–41.
- Hoff, H. 2001. Climate change and water availability. In: Lozán, J.L., Grassel, H., Hupfer, P. (Eds.), Climate of the 21st Century: Changes and Risks, 315-321. Wissenschaftliche Auswertungen, Hamburg.
- Hubacek, K., J. Kronenberg. 2013. Synthesizing different perspectives on the value of urban ecosystem services. Landscape and Urban Planning 109(1),1–6.
- IPCC, Intergovernmental Panel on Climate Change, 2007. IPCC Fourth Assessment Report (AR4).
- Johnson, W. T., Lyon, H. 1991. Insects that feed on trees and shrubs. Cornell University
- Press.
- Kaplan, R., Kaplan, S. 1989. The Experience of Nature: A Psychological Perspective. Cambridge University Press, New York.
- Koricheva, J., Larsson, S., Haukioja, E. 1998. Insect performance on experimentally stressed woody plants: a meta analysis. Annual Review of Entomology 43, 195-216.
- Kuo, F.E. 2001. Coping with poverty: impacts of environment and attention in the inner city. Environ. Behav. 33, 5–34.
- Kuo, F.E.,Sullivan, W.C. 2001 Environment and crime in the inner city. Environ. Behav. 33, 343-367.
- Kuo, F.E. 2003.The role of arboriculture in a healthy social ecology. J. Arbori. 29, 148–155.
- McPherson, E.G. 1994. Energy-saving potential of trees in Chicago. In Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. General Technical Report NE-186. E.G. McPherson, D.J. Nowak, R.A. Rowntree (eds). U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Radnor, PA, pp. 95–115.
- McPherson, E.G., Nowak, D.J., Rowntree, R.A. 1994. Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. General Technical Report NE-186. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Radnor, PA, pp. 201.
- Mihajlović Lj. (2008): Forest Entomology, University of Belgrade, Faculty of Forestry, Belgrade.
- Nowak, D.J. 1994. Air pollution removal by Chicago's urban forest. In Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. General Technical Report NE-186. E.G. McPherson, D.J. Nowak and R.A. Rowntree (eds).

U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Radnor, PA, pp. 83–95.

- Nowak, D.J., Crane, D.E., Stevens, J.C., 2006. Air pollution removal by urban trees and shrubs in the United States. Urban Forestry and Urban Greening 4, 115-123.
- Raupp, M.J., A.B. Cumming, E.C. Raupp. 2006. Street tree diversity in eastern North America and its potential for tree loss to exotic borers. Arboriculture & Urban Forestry 32(6):297–304.
- Roloff, A., S. Korn, S. Gillner. 2009. The climate-species-matrix to select tree species for urban habitats considering climate change. Urban Forestry and Urban Greening 8, 295-308.
- Sieghardt, M., Mursch-Radlgruber, E., Paoletti Couenberg, E., Dimitrakopoulus, A., Rego, F., Hatzistatthis, A., Randrup, T., 2005. The abiotic urban environment: Impact of urban growing conditions on urban vegetation. In: Konijnendijk, C.C., Nilsson, K., Randrup, T.B., and Schipperijn, J., (Eds.). Urban Forests and Trees. Springer. 281-323.
- Sinclair, W. A. and Lyon, H. H. 2005. Diseases of trees and shrubs. 2nd ed. Cornell University press, Ithaca, New York
- Sutton, B.C. 1980. The Coelomycetes. CAB - Commonwealth Mycological Institute, Kew, Surrey, England.
- Tubby, K.V., Webber, J.F. 2010. Pests and diseases threatening urban trees under a changing climate. Forestry, 83, 451-459.

SAŽETAK

Dendropark Šumarskog fakulteta u Skoplju, Makedonija, osnovan je kao "muzej na otvorenom" sa zbirkom šumskog drveća i grmlja. Zbirka je zasađena 1950. godine na površini od 4,05 ha i obuhvaća 336 taksona iz autohtone makedonske i balkanske endemske dendroflore, zajedno sa novim vrstama iz različitih područja svijeta. Aktualni popis bio je napravljen kao osnovno sredstvo za monitoring. Dendropark, poput ostalih botaničkih vrtova širom svijeta izvanredan je resurs koji uveliko olakšava otkrivanje potencijalnih invazivnih prijetnji za zastupljene vrste šumskoga drveća. Popisana populacija obuhvatila je 444 stabala, koja pripadaju 43 porodicama. Tri najzastupljenije porodice bile su: *Pinaceae* s 21 vrstom (19,4 % popisanih biljaka), *Cupressaceae* sa 16 vrsta (15,8 %) i *Rosaceae* sa 18 vrsta (7,4 %). Provedeno istraživanje iz 2014. godine procijenilo je tadašnje zdravstveno stanje prema kojemu 33,8% ukupnog drveća ocijenjeno kao dobro, 1,8 % kao relativno dobro, 31,1 % kao prosječno, dok ih je 24,5 % ocijenjeno kao loše. Približno 4,1 % drveća je bilo ocijenjeno kritično, tj. u stanju propadanja, dok je 4,7 % stabala bilo mrtvo. Procjena zdravstvenog stanja drvenastih vrsta u Dendroparku mogla bi biti dragocjeno sredstvo i od velike koristi i osobama koje planiraju i donose odluke. Također, ona može pružiti i potrebne informacije o kvaliteti, količini i položaju prirodnih resursa u urbanim područjima. Utvrđivanje promjena u sastavu vrsta i prisutnosti štetnika i patogena pruža dodatan uvid, koji olakšava očuvanje zdravih urbanih šuma.

KLJUČNE RIJEČI: *Platanus orientalis* L., pepelnice, potkornjaci