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HUNGARIAN AGRICULTURAL RESEARCH

September 2019

Environmental management, land use, biodiversity

FROM CONTENTS

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EXAMINATION OF GROWTH OF IRRIGATED ENERGY PLANTATION WITH EFFLUENT WATER FROM ORIGINATED IN AGRICULTURE

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ABSTRACT

Agricultural technology waters are most often deposited in surface water receptacles, which cause significant environmental pressures. Nowadays the preservation of the water quality, the decreasing of the soil stress, and applying energy and watersaving irrigation methods play more and more important role in the world. The National Agricultural Reasearch and Innovation Centre's (NARIC) Forest Research Institute and the Research Institute of Irrigation and Water Management are in a common cooperation, and we have established an experiment at the 0153/21-C parcel number site of Szarvas in 2013. The experiment was set up for investigate the usability of the fish farm effluent water in energy plantation to increase biomass production. In the experiment we applied two different tree species – willow and poplar – and investigated their yield using different combinations of two irrigation water sources. Two irrigation doses were applied using sprinkler irrigation method. During the season we analyzed the effect of different irrigation methods on these species with analyzes of phenology parameters and root growth. We were looking for an answer which nutrient treatment and which variety provides the highest biomass in a two-years crop rotation, and how soil conditions changes. In order to examine the soil status, soil physical (pentration resistance, soil moistrure content, bulk density), chemical (pH(H_2O), pH(KCl), organic matter), and biological (abundance, biomass and morphotypes of earthworms) parameters were measured.

keywords: wastewater, fish effluents, irrigation, energy plantation, biomass, poplar, willow

INTODUCTION

Arable land crop production today is around 4.3 million hectares, accounting for about half of Hungary's territory. With the current support system, arable land is hundreds of thousands of hectares in size, where it is difficult to guarantee profitability through the cultivation of conventional crops. These areas are predominantly drought-sensitive and / or, in many cases, water-prone, prone to inland waterways, as well as areas of low habitat value, extreme water and nutrient management, mainly sand or sandy loam. Agriculture will continue to play a key role, as these production areas are generally located in less-favored areas, both socially and economically, and neither can decommissioning or changing cultivation (eg. from arable to lawn or forest) produce results.

In the future, the establishment of woody energy plantations in order to preserve the population of the countryside may be an excellent solution, thus also providing a lucrative agricultural activity for the population. As a general rule, all the agricultural soils used in Hungary are suitable for the cultivation of a fast growing tree species. Because these tree species (eg. *Populus spp., Salix spp.*) Usually tolerate unfavorable habitat conditions, they can be planted in inland or floodplain areas, where other agricultural plants can no longer be grown because they do not survive. Nonetheless, certain plants (eg. *Robinia spp.*) Can be safely grown under particularly dry, drought-prone conditions (Ivelics, 2006; Barkóczy et al., 2007). Around 60% of Hungary's arable land is prone to erosion and / or deflation, with vulnerable areas ranging from 2 to 2.5 million hectares (Gyuricza, 2007). The planting of short rotation plantations in these areas offers excellent soil protection as almost year-round soil coverage can be achieved.

Figure 1: Energy willow plantation (Szarvas). (Photo: Beatrix Bakti)

The development of agricultural water management, including irrigation, will be an important agricultural development target for the coming years, which can greatly contribute to reducing the sector's climate exposure and increasing production potential. In addition, there will be a strong emphasis on the secondary utilization of water used in aquaculture systems, which can be a key area of the circular economy. One possible way to do this is to transfer agricultural wastewater to energy crops. Irrigation with wastewater that threatens surface waters can achieve higher biomass yields in woody plantations, and the resulting woody biomass can be included in energy production, reducing the operating costs of the wastewater plant itself.

Some willow and poplar varieties can reach a height of 4-5 m already in the first year, which has an effect of reducing wind erosion by 25-30 times

Figure 2: Application of microspray irrigation method in energy plantation (Photo: Beatrix Bakti)

their height, this means that it extends from 100 to 150 meters, which means that plantations play an important role in protecting the surrounding areas, such as soil lanes and forest strips. Total carbon sequestration is significantly higher for short rotation plantations than for annual crops, but less than for mature forests. The increased carbon concentration in the soil of short rotation plantations is mainly due to the high annual foliar disturbance, on average 1-5 t / ha / year (Boman-Turnbull, 1997). Thus, the main mass of easily absorbable carbon source for the soil-dwelling microorganisms is the foliage disorder resulting from deciduous fall (Huang and Schoenau, 1996). As a result of microbial activity during the decomposition of fallen leaves, the soil is more crumbly and the humus layer is more nutrient rich.

Soil is a natural habitat for many organisms. The study of earthworms of soil organisms (edaphon) is of great importance because their role in the soil ecosystem is proven in the temperate zone, thus it is an important indicator of the biological state of the soil (Satchell 1983). Earthworms, along with their passages, play an important role in the physical, chemical and biological processes of soil. The earthworms make their soil active by loosening and mixing the soil, thus reducing the risk of soil compaction. Through mixing action, plant residues move from the surface to deeper layers, and inorganic materials from the lower layers to the surface (Bakti et al., 2017). Earthworm excrement is an organo-mineral material with special properties, which, when mixed with other substances (urine, mucus), is involved in the formation of clay-humus complexes, soil aggregates and soil structure. Vertical earthworm passages, such as pores, also promote rooting of plants into deeper layers, aeration of ground and subsoil, and soil water management.

MATERIAL AND METHODS

The smallest field experiment on irrigated plantations in 2013 resulted in 18 parcels of 13x10.5 meters in size on a total of 0.3 ha.

The plots are randomized, with two plant species, three treatments and three replicates. The poplar clone is a state-recognized artificial hybrid (*Populus* × *euramericana cv. Kopecky*) created by Ferenc Kopecky at NAIK ERTI's Sárvár experimental station, while the willow is also a clone selected by NAIK ERTI (code 82).

Two water qualities and three irrigation doses were used in the treatments of the experiments. The effect of effluent from an intensive fish farm in two treatment cycles was investigated in both treatments. The irrigation water doses are 60 and 30 mm, designated as H60 and H30. The third treatment (irrigated control) was done by irrigating the water of the Bikazugi oxbow (Körös) in the immediate vicinity of the experimental area with a dose of 30 mm irrigation water, designated K30. Water quality of the backwater, 90/2008. (VII.18) MARD decree on all water quality indices and can be classified as excellent for irrigation and applicable to all soil types (Kun et al., 2017). The use of wastewater for irrigation is limited by the high sodium, bicarbonate and total dissolved salt content. Water was applied to the plantation in the year of planting and in the second year with a reel-drum irrigation system (due to lower plant height), and in the third year, in 2015, we switched to drip irrigation.

The applied technology: simple-row arrangement 1,5 metres between the simple rows which makes it easier to carry out mechanised treatments. The cuttings were planted at 50 cm spaces. Twenty cm long one-year old cutting without any roots were used for planting. In each block there are 216 clones from each species.

RESULTS

The soil type of the site is meadow soil with high clay content through the BC2 soil horizon. The groundwater table is under 110 cm, the soil profile depth was 120 cm. In the soil profil we have found six horizons. The upper horizons (A, AB, and B) contain lime pins, at the BC1, BC2 horizon we have experienced iron, and manganese knots. The C horizon contains manganese and lime supply. Mostly the border of the horizons are sharp, excluding the BC2 where this is gradual.

Investigating the soil profile (Figure 3.) the depth of the profile was 120 cm, where we found the groundwater table at 110 cm. The vegetation around the profile is willow clone 82, poplar clone 800, and mixed. The parent rock is river drift.

Soil horizon	Depth (cm)	Physical properties	Structure	Packing densiti	Roots	Border
A	0-16	clay	friable	medium compact	hair roots and roots	sharp
AB	17-22	clay	friable	heavy	rootless	sharp
B	23-46	clay	prismatic	medium	less hair roots	sharp
BC1	47-78	clay	without structure	low	primary roots	sharp
BC2	79-115	sandy clay	without structure	none	-	gradual
C	116 -	sandy clay	without structure	none	-	-

Figure 3: Soil profile

We examined the density of the soil with penetrometer and with the analysed results we have made a map from the examination site (Figure 4).

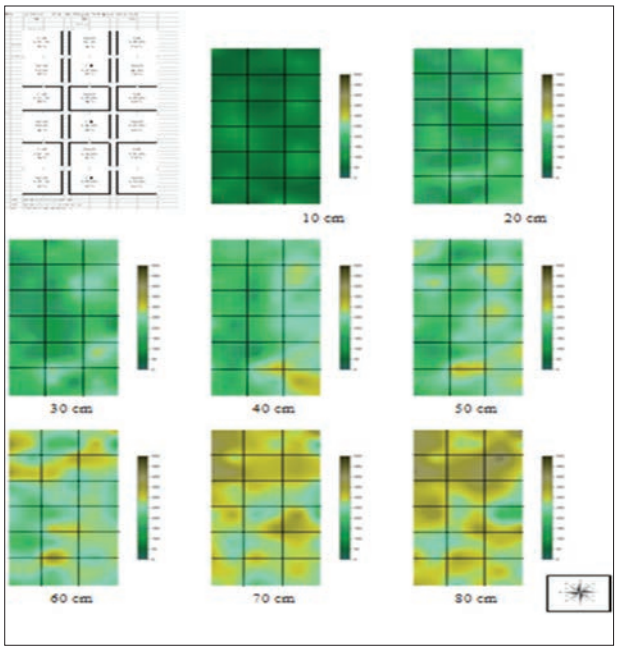

Figure 4: Soil density map from the examination site

We can determine the organic matter content of soil samples that the highest values were measured in irrigated treatments in the experimental area(Figure 6.). The nutrient supply capacity of the effluent water had the highest organic matter content at a depth of 0-15 cm in the topsoil: 3.6%. The lowest values were measured in areas treated with natural Körös water, which was only around 2%. In the field of energy plantation we also compared the number of earthworms and biomass. It can be stated that the highest amount of earthworms and biomass were measured with the higher organic matter content in the area treated with agricultural wastewater. The reason for the higher earthworm activity in irrigated areas is that significant amounts of plant residues (dead fallen leaves) on the soil surface retain moisture and also increase soil organic matter. A sufficient supply of earthworms and minimal soil disturbance results in a smooth living space and the formation of horizontal and vertical passageways. Due to the agitating and channeling activity of earthworms, the pore system is well developed and the soil is highly structured with excellent crumb structure. Vertical earthworm passages, as pores, also help rooting plants into deeper layers and venting the top and bottom.

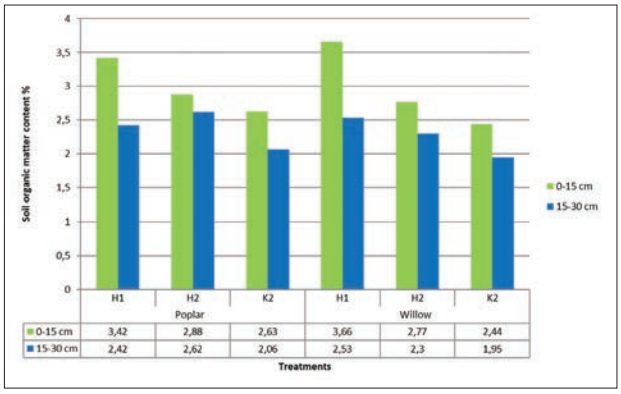

Figure 5: Soil organic matter content of soils

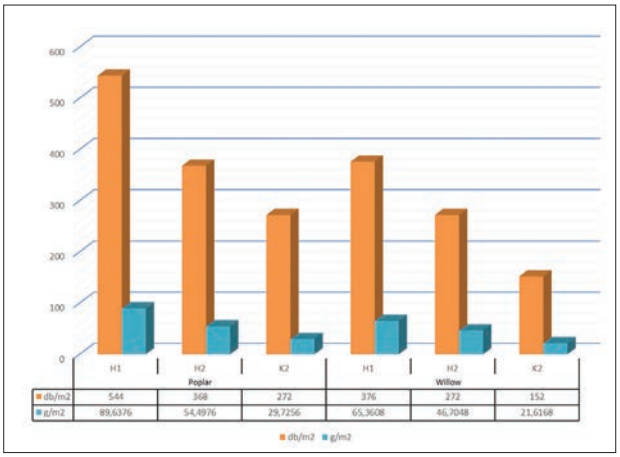

Figure 6: Average biomass (g/m²) and abundance (ind/m²) of earthworms

During the root morphological examination (Figure 7.) of the increased irrigation treatment, 3 to 3 sample units were removed from each treatment. We removed the soil particles from the root system, determined the main growth directions of the root fibers, their thicknesses, and determined the root masses. Based on our results we can conclude that in case of the application of 60 mm of water for irrigation of agricultural origin, in the case of both noble and white willow root growth is mainly horizontal. The rootstocks that start to grow are much thinner, shorter, and larger in weight from the close buds of the root soil. The root fibers are short, suggesting that the vegetation takes the necessary water and nutrients from the immediate environment of the individual as a result of intensive irrigation. Conversely, the use of smaller, two-week irrigation was mainly due to the root-close buds of the cuttings. In this case, the thicker and longer root fibers are characterized by vertical growth in addition to horizontal growth. In the naturally treated Körös water, this phenomenon is even more pronounced. We found a definite vertical growth because it can absorb the necessary nutrients from a deeper layer of soil. The results of several years of root system studies suggest that this root form is typically retained in subsequent years.
The highest biomass yield per hectare of the experimental plots was measured in shallow water irrigated twice with agricultural effluent, measured at 23.7 and 22.3 atrotons (units used to determine the absolute dry weight of

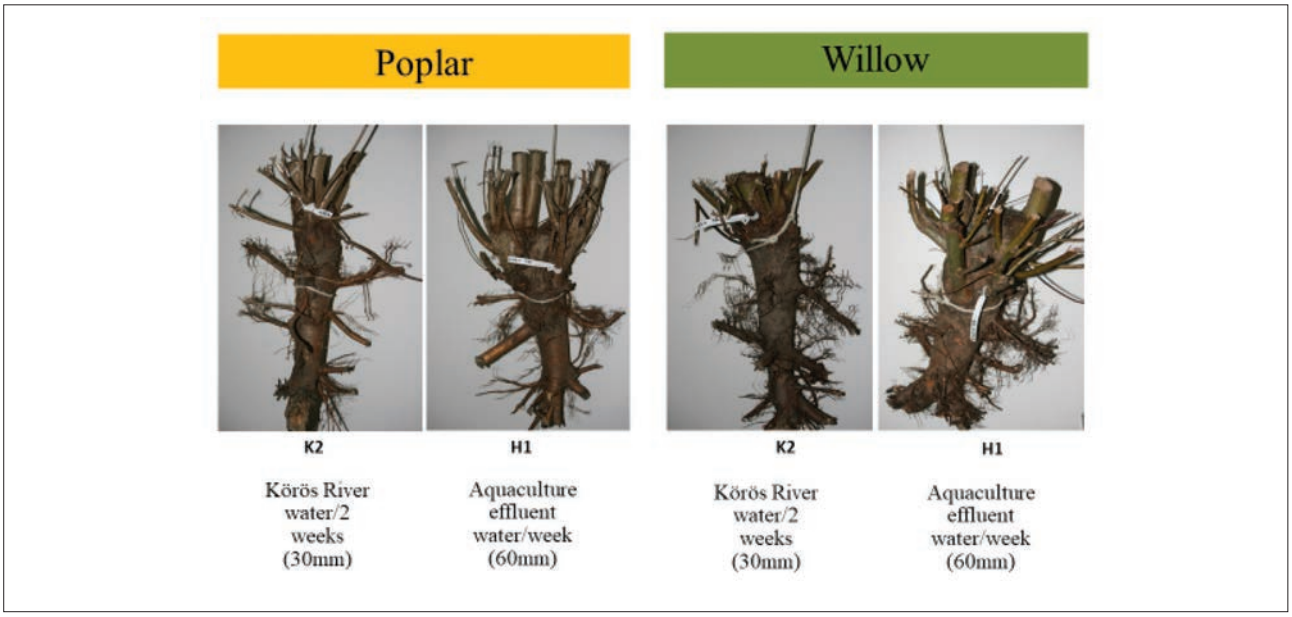

Figure 7: Root morphological examination

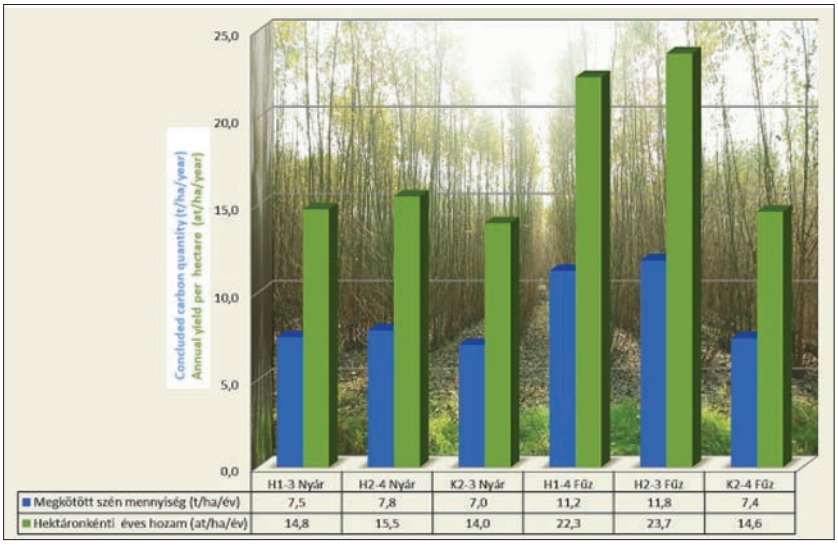

Figure 8: The annual yields of poplar and willow per treatments

wood) (Figure 8.). Thus, the highest values of bound carbon in terms of absolute dry matter content of the wood yields were measured in these treatments. Higher yields were also observed in plots treated with effluent from fish farming. The annual yields of the plots of natural origin treated with Körös-water remained lower for both tree species, and lower biomass mass was measured. In the case of white willow we measured 35% less biomass compared to areas treated with single effluent and 39% with double effluent. Based on these, it can be concluded that agricultural effluents have a biomass yield increasing effect in our experimental area.

DISCUSSION

Our aim is to develop an environmentally friendly cultivation technology based on the use of nutrient-rich waters of agricultural origin for irrigation purposes. The direct aim of our research is to investigate the irrigation utilization of high nutrient and salt water from an intensive fish farm in a woody energy plantation, with special attention to the soil and plant effects of irrigation management. We are looking for an answer to how agricultural wastewater and effluent water can be utilized in crop production practices; ultimately, our goal is to develop a set of criteria and conditions that provide specific guidance for the sustainable irrigation of similar or less polluted wastewater in energy tree plantations.

CONCLUSIONS

One of the greatest risks of domestic agricultural production is its exposure to changing climatic conditions. In the period preceding the change of regime, the irrigated area was almost 400,000 hectares, which today has fallen below 100,000 hectares, which is less than 3% of the total arable land. With this low share, we are only

in the back row among the countries of the European Union. Agricultural development in the coming years must focus on improving agricultural water management, including irrigation, if we are to reduce the sector's climate exposure and increase emissions. There are many water-intensive activities in agriculture that allow the secondary use of the water used. One way to do this is to irrigate the energy plantations outlined above, which, in addition to supplying moisture, also provide plants with nutrients. The cultivation of energy plantations can bring several practical benefits as it, in combination with irrigation for less favored areas, stabilizes agricultural production in the long term.

Our goal is to develop an environmentally friendly cultivation technology that utilizes nutrient-rich waters of agricultural origin for irrigation purposes. By retaining water in agricultural areas, we can decontaminate surface recipients and also recycle them.

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SITEVIEWER A DECISION SUPPORT TOOL FOR FOREST MANAGEMENT

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ABSTRACT

Climate change requires effective adaptation oriented decision making. We developed the SiteViewer software as a GIS based impact assessment tool in order to help forest managers assessing yield class changes of major tree species. Besides yield class assessment the software provides options for the most suitable tree species of any given site, too. Additionally, SiteViewer supports the practical utilization of the new digital site-maps, compiled by the researchers of NARIC FRI and HAS RISSAC. With the integration of online GIS resources, the application enables users to access site maps, and climatic datasets to use them. The targeted users of this software are the forest planning experts and forest owners. We provide information about site conditions that are essential to determine forest utilization options. The map resolution of the software is 1 ha / pixel, and it covers the whole territory of the country.
SiteViewer supports the process of forest planning by providing information on climatic and soil conditions of selected production sites, and revealing differences in yield potential of larger forest sections.
The software can be download from the website of NARIC FRI Geoportal (www.ertigis.hu) after clicking on „Térképszolgáltatások" menu item.

Keywords: decision support tools, climate change, forest management planning

INTRODUCTION

Climate change requires effective actions aiming to improve adaptation capacities. The need for adaptation is more crucial in forestry than in other fields of agriculture due to the long term production phase and, the restrictions of technological interventions. These limits make forestry one of the most extensive, site depending sector that has to adapt to site conditions through appropriate species selection (Settele et al. 2014).
In the last decade remarkable research efforts were made to assess and reveal the exposure of forestry sector to climate change. Research aimed to discover the expected impacts of projected changes on forest ecosystems by first of all evaluating the vulnerability of main forest stands (Bontemps and Bouriaud 2013; Dumroese et al. 2015; Misi and Náfrádi 2017).
One aspect of these research actions was focusing on the assessment of growth rates of species under changing climate, and to elaborate the most appropriate species choice options for changing or already changed sites. For this reason in the first stage we prepared a countywide fine scale pilot project for Zala County to establish the basis of the development of site-species, and site-growth statistical modelling within the framework of Agrárklíma TÁMOP project (Illés et al. 2014). In the second stage we prepared a countrywide but coarse resolution model for the main stand forming species within the AGRATÉR project (Illés and Fonyó 2016). Finally, based on the results of the coarse – countrywide and the fine – countywide approaches, we were able to compile the first implementation of a fine scale and also countrywide statistical model for growth and species pattern changes. This latter model was prepared according to the climate change predictions following RCP 4.5 scenario.
In this paper we present a brief description of the datasets which were used for model development together with the applied statistical methods, and the front-end application of developed software called SiteViewer.

MATERIALS AND METHODS

For the statistical model development between the site conditions and growth (yield class) of tree species we used the following data sets:

Climate data

Climate data was taken from the Climate EU database (Wang et al. 2016) that represents the whole territory of Europe and it provides climatic and bioclimatic variables as rasters. In this database climate data is downscaled to 1 km by 1 km spatial resolution.

By default, the following periods are available: 1961-1990 (baseline); 1981-2010; 2041-2070; 2071-2100 (https://sites.ualberta.ca/~ahamann/data/climateeu.html).

Soil data and soil related data

Soil data was taken from the new digital soil map series of Hungary that was created by our research team (RISSAC – NARIC FRI). The map series compilation was based on the data of almost 60,000 soil profile locations throughout the country. Soil data maps spatial resolution is 1 ha (100 m by 100 m) (Pásztor et al. 2018).

The soil dataset contained factor variables including genetic soil type, soil depth category, and texture class.

In an additional map layer we provide information on possible occurrence and type of extra water supplies beside precipitation. This map layer categorizes sites having no additional water supplies, or sites having surface accumulated water sources, or sites having additional water supply from groundwater sources.

Forest growth data

For forest data we used the National Forestry Database selecting the seven most frequent stand forming species. These species are as follows: beech (Fagus sylvatica), black locust (Robinia pseudoacacia), Austrian pine (Pinus nigra), Scots pine (Pinus sylvestris), sessile oak (Quercus petraea), pedunculate oak (Quercus robur), and Turkey oak (Quercus cerris). Only those stands were involved where the area proportion of targeted species reached or exceeded 75%.

Prediction methods

The climate – soil – forest datasets were joined and we set up the yield class – site condition models species by species applying random forest algorithm in R Studio. The models' accuracy assessments were done by test runs on separate datasets for each species. Accuracy was found between 65-92%. For the predictions we used the RCP 4.5 emission scenario based ensemble climate projections for the period of 2041-2070 as boundary condition.

Application development

The resulted maps serve as core data for SiteViewer application. The program was developed as a .NET based Windows program for end users. Map data are stored in our GIS server and the necessary data is provided to each standalone program instances via Internet connection. This way we can continuously improve and maintain the map databases, while the users do not need to upgrade their front-end application.

Additional services are also included into this desktop application, such as forest stand map thanks to erdoterkep.nebih.gov.hu, administrative boundary map of municipalities, and forest compartment finder to help navigation.

The program also provides access point to the data of our network of forestry meteorological stations.

RESULTS

We present here some utilization options of SiteViwer. Not all the options are covered in this chapter due to size limitations. For further details check the help documentation of the software.

An obvious way of utilization is using map overlays (Fig. 1). All the included map layers can be overlaid and by setting transparency of layers the application offers the option of visual data interpretation for larger areas.

Getting more in the details SiteViewer provides an easy way for evaluating the site condition of selected forest compartments – found even by the compartment search module or by map navigation (Fig. 2).

The selected compartments' site data and the most appropriate target species together with their expected growth rates under recent climate are reported to the user. Additional tables provide information on future growth rates predicted under future climate conditions. The bioclimatic indicators and climate data are also provided. Result tables can be exported to MS Excel files where not only the compartments' descriptors and their site data are listed but also the X, Y coordinates of the compartments are involved.

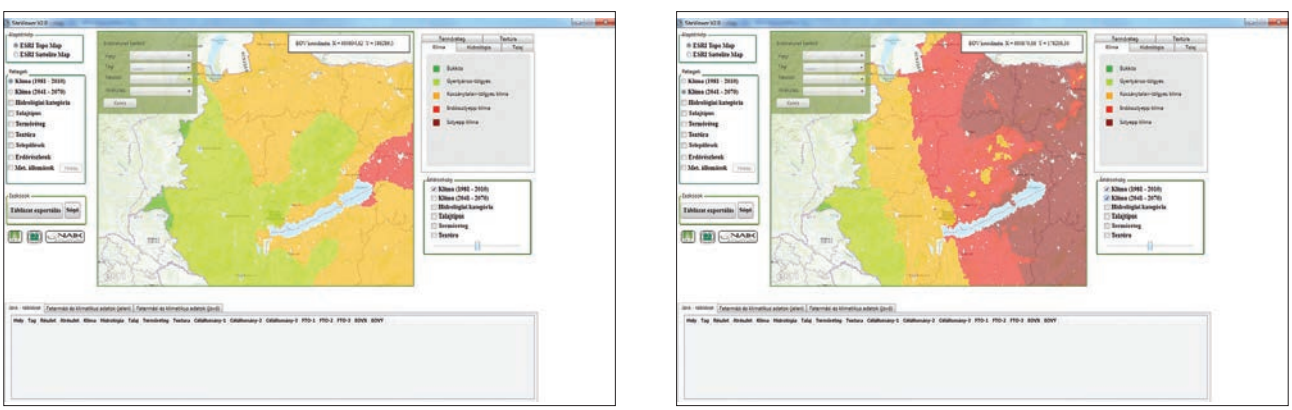

Figure 1: Example of recent (left) and future (right) forestry climate zone maps in the software

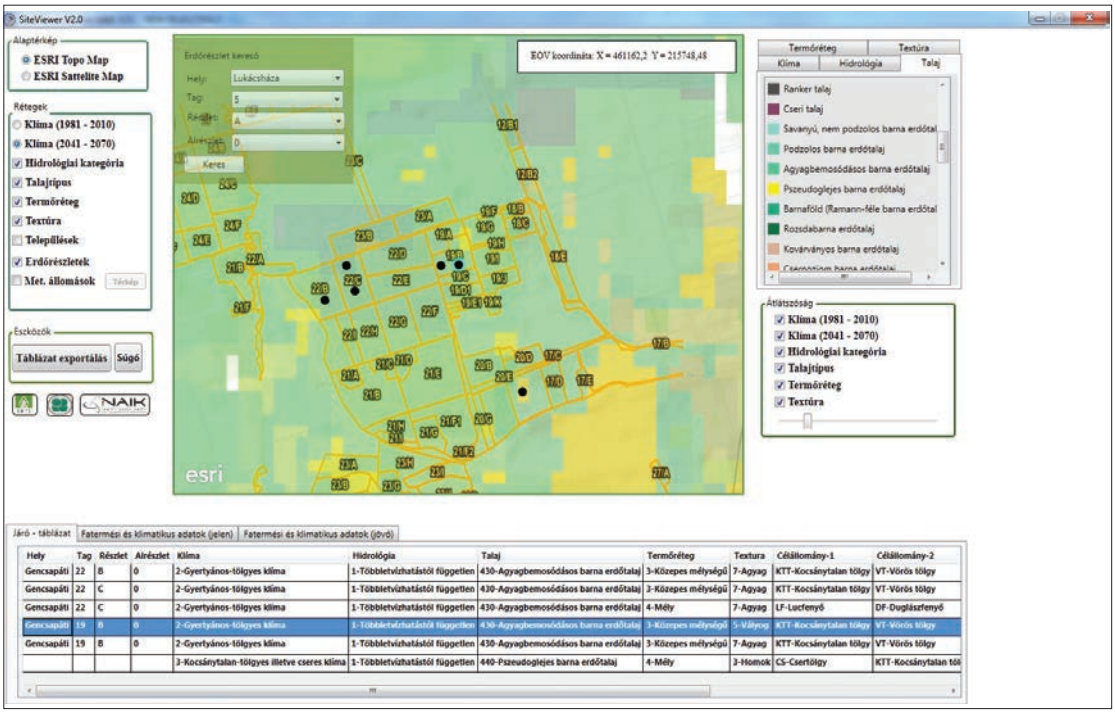

Figure 2: Forest stand selection and site evaluation with SteViewer

Figure 3: Afforestation site preliminary site evaluation and identified site patches (inner image) for sampling using SiteViewer

Another useful option in SiteViewer is the compilation of preliminary site and species composition maps as a preparatory step for afforestation. Using the software one can easily create virtual sampling for preliminary site-evaluation. Based on the results a decision can be made whether it is worth at all to think about afforestation project on the given site. This virtualized site exploration however, is better to use for creating sampling design for soil sampling before the afforestation takes place. Based on the underlying satellite image and the virtualised sampling's result the major site types can be assessed and the number of sampling points can be optimized by using the site patch map via e.g.: tessellation (Fig. 3).

DISCUSSION

There is a huge variety among forestry decision support systems (Mátyás et al. 2018). This has been originating from the long history of their developments sincs the 1980s. Nowadays, there are almost 70 different systems listed on forstsdss.org. These DSS tools in the beginnings were developed to support bussiness related management decisions. Later, tasks became more diverse, with more mainstream systems focusing on, for example, integrated landscape assessment, or the vulnerability of forests to abiotic damages, or the suitability of species to local site conditions, or even assessing the effects of afforestation. Some of these systems have spatial representation and some have not. The major systems offer the option of spatial analysis as well. Regarding the basic level of analysis most of them report the results on stand level, others have spatial units such as square km or hectare (forstsdss.org).

In this context, our system's main goal is to evaluate climate change impact on the growth of tree species. It implements a random forest based site-climate-yield class model. For the site evaluation our system incorporates the Hungarian expert system for forest site evaluation and extends it with yield class assessments for future climate according to newly appearing climate-site combinations.

CONCLUSIONS

Decision support systems has an increasing role in forest management. Not only for the reason of improving timber production processes but for the reason of sustainability of forest ecosystems exposed to changing climate. We made only the first step towards a sectoral DSS, which would help to identify the best solutions including management, protection and other aspects too. Our results are promising and this encourage us for further efforts. In next steps we have to integrate other modules e.g. for selection of appropriate propagation materials and to perform abiotic damage risk assessment.

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FOOD WASTE – A GENERAL OVERVIEW AND POSSIBLE SOLUTIONS

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ABSTRACT

Our current knowledge on food wastage raises important questions about the severity of the problem. However, we only rely on estimates and due to the widely differing methods used for determining the magnitude of food wastage, published results could not be directly compared and evaluated (Bräutigam et al. 2014). Moreover, in several cases contradictory outcomes were released in the same topic. Nevertheless, in the past few decades, researchers; academics; authority experts; policy makers and many other stakeholders of the food chain have begun to counteract against excessive losses. Although several positive results have been achieved over this period, it is clear that we are facing major difficulties to bring about significant changes regarding food waste generation. What is clear now, that applying adequate research methods and targeted consumer communication will be part of the solution how the issue of food wastage as an outstanding challenge for the society can be hindered. In this paper we intend to report briefly about the research activity so far, and the current legal background of the field. We would also like to introduce our communication campaign on household food waste prevention, '*Wasteless*' and other relevant projects of this field.

INTRODUCTION

Ever since mass production appeared, the generation of food waste and food losses along the entire food supply chain has been considered as an increasingly troublesome issue. In the first period of food waste research activity, main interest was raised to the elaboration of food waste management techniques (Szabó-Bódi 2018). In the last decade of the 20th Century, researchers put more emphasis on recycling technologies of food waste. However, since the beginning of the new millennium stakeholders are increasingly reporting on the importance of prevention. From the early 2000s, food wastage in households became also part of the target areas (Aschemann-Witzel et al. 2015), and new publications have been issued on the socio-demographic background of food waste generation (Abeliotis et al. 2015).

Exact numbers

An estimated one-third of food produced worldwide gets wasted along the entire food chain, which equals to 1.3 billion tons of bio-waste (FAO 2011). From the aspect of the place of origin, the main difference between the regions of the World is that while in developing countries the highest amounts of losses generated due to the lack of infrastructure (transportation, storing, cold chain); in case of developed countries food is mostly thrown away in households as a result of unconscious consumer behaviour (WRI 2013). Narrowing the study area to Europe, the estimated mass of food waste was 89 million tons in 2006, which equalled to 179kg per capita (BIOIS 2010). According to the *Estimates of European food waste levels* issued by Food Use for Social Innovation by Optimising Waste Prevention Strategies (FUSIONS), households are responsible for 53% of the total food waste in the EU. Food processing produces 19%, followed by food service and food production, with 12% and 11%, respectively. The rest 5% is connected to wholesale and retail. From these data we may draw the conclusion that the actors most responsible for food wastage are households.

1.8 million tons of food is wasted every year in Hungary (BIOIS 2010). In a recent study Szabó-Bódi et al. (2018) conducted a one-week food waste measurement survey with the participation of 100 Hungarian households. Based on their estimations, a Hungarian person produces 68 kg of food waste annually. In this study three different food waste categories were distinguished, namely: avoidable (the real wastage), unavoidable (non-consumable parts of the food) and potentially avoidable (depends on the preference of the individual). Almost half of the measured food waste was considered to be avoidable. The most dominant types of discarded foods were meals (40.08%), followed by bakery products (19.63%). Fresh vegetables and fruits together had a remarkable ratio as well (16.91%). Dairy products (8.79%), soft drinks (5.76%), and other, less prevalent food types were on the bottom of the list (Table 1).

Table 1: Composition of food waste in Hungarian households (Source: Szabó-Bódi et al. 2018)

Avoidable food waste	Proportion (%)
Meals (home-made and pre-prepared)	40.08
Bakery products	19.63
Fresh vegetables and fruits	16.91
Dairy products	8.79
Mineral water, soft drinks, coffee	5.76
Processed animal products	2.25
Canned foods, pickles	2.12
Raw meat	0.84
Sauces, toppings (ketchup, mustard, etc.)	0.83
Grain products: flour, semolina	0.77
Yeast, muesli, corn flakes, raisins, puffed rice, baking mixtures	0.71
Marmalades, jams	0.40
Confectionery and snacks	0.28
Eggs	0.24
Fats (butter, margarine, lard, etc.)	0.18
Frozen meats, vegetables	0.16
Packed spices (rosemary, marjoram, parsley, etc.)	0.05
Total	**100.00**

Several studies report about the connection between demographical characteristics and wasteful behaviour. However, controversial results were published in some cases. In 2014, Nébih launched a consumer survey on food wastage with a large number of participants (n=1006). Examining the demographical background, they found that extreme levels of wastes are more characteristic of male consumers, as 30% of female respondents claimed to be completely waste avoiding, while in case of males it was only 17%. This phenomenon was confirmed by the above discussed 100 household survey (Figure 1). The effect of income level on the extent of food wastage is a highly argued topic among international research communities. Farr-Wharton et al. (2014) confirmed a linear relationship, regarding that the low income consumers show less wasteful behaviour compared to

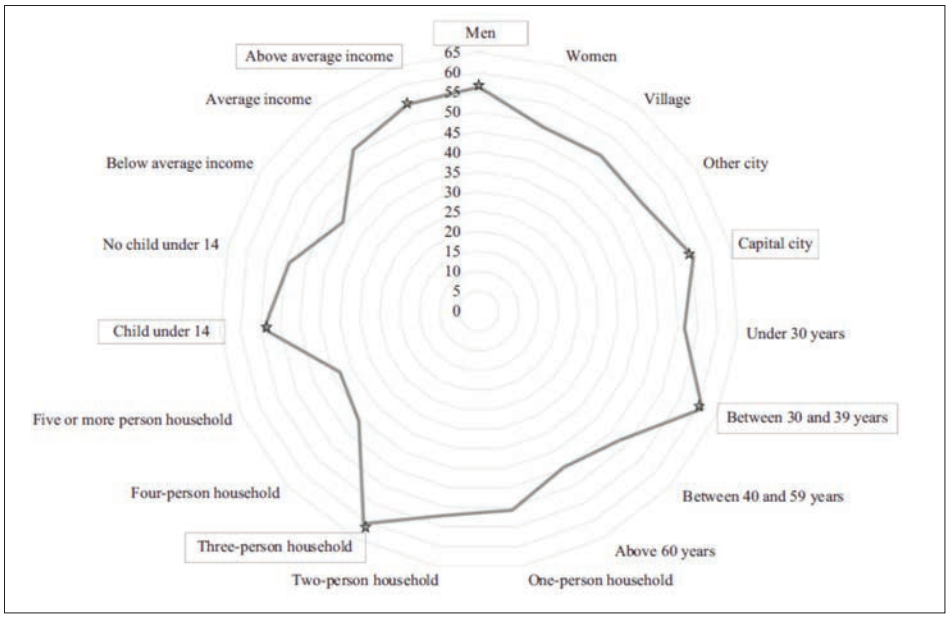

Figure 1: Demographical background of food wastage (Source: Szabó-Bódi et al. 2018). The groups in the framed texts showed more wasteful behaviour

Table 2: Connection between age and food wastage (Nébih research)

When was the last time that you discarded food?	Age				Average
	Under 30 years	30-39 years	40-59 years	Above 60 years	
Yesterday	23,89%	17,16%	13,41%	8,81%	15,81%
About a week ago	37,22%	37,28%	34,15%	18,31%	31,74%
About a month ago	30,55%	31,95%	32,62%	26,10%	30,31%
About a year ago	1,67%	4,14%	3,66%	7,80%	4,32%
It was so long ago that I don't remember	6,67%	9,47%	16,16%	38,98%	17,82%
Total	100,00%	100,00%	100,00%	100,00%	100,00%

more wealthy people. In our latest research conducted in 2018, we found that in case of consumers under 30 (Table 2) and families with children under 15 years food wastage is significantly higher than among other people in the same demographical category.

Legal background

At first hand the definitions of 'food losses' and 'food waste' were issued by FAO (2011). According to this definition "Food losses refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption." While 'food losses' are characteristic to production, post-harvest and processing stages (Parfitt et al. 2010), 'food waste' occurs at the end of the value chain (retail and final consumption), and rather affected by the behaviour of retailers and consumers.

Figure 2: Food Waste hierarchy (Source: http://maradeknelkul.hu/wp-content/uploads/2019/03/maradeknelk%C3%BCl_piramis_ENG.jpg**)**

Besides researchers and food business operators, policy makers have taken steps towards the reduction of food wastage and have tried to establish a legal background to make a frame for the problem solving. In the EU the main directive on waste is the Directive 2008/98/EC, which is the legislative framework for the handling of waste in the Community. Accordingly, all activities must be carried out in such a way to ensure: waste prevention; the reduction of the amount and hazardousness of waste; waste recovery; and environmentally friendly disposal (Kürthy et al. 2019). Food business operators always have to stick to the 'waste hierarchy' (Figure 2).

In a recently released study, the National Agricultural Research and Innovation Centre of Hungary (Kürthy et al. 2019) investigated the general opinion of food processing operators on legal amendments and new possibilities for legislation in the field of the prevention of food losses. Fairly diverse viewpoints between the participants depending on the sector were recognized. However, some conclusions could still be drawn as to what kind of regulatory options are considered appropriate by professionals of the food processing industry. For enterprise directors over the age of 60, technological development and relaxation of requirements, while under the age of 40, consumer information, consultation and training were considered to be the most important interventions. Tax benefits also played an important role to help reducing the number of "black workers", as bypassing taxes they are much more wasteful.

Consumer campaigns

Based on the numbers presented above, it might be well noticed that we discuss an issue for which the entire society should take responsibility. Nébih recognized food wastage as a tremendous burden on the economy, the environment and therefore the whole society, and started its awareness raising programme *Wasteless*, with the financial support of the European Union's LIFE sub-programme. The main goal of the four years period project is to find the best methods contributing to food waste prevention along the whole food chain. For this purpose, we set four specific objectives:

1. Decreasing the proportion of food waste among Hungarian families, through changing consumers' attitude and behavioural patterns
2. Increasing the food waste prevention related awareness and the level of knowledge of children attending primary school
3. Collecting good practices which contribute to the prevention of food waste generation in other sectors of the food chain, and based on that, elaborating guide books for the concerned stakeholders
4. Collaboration and cooperation with other EU member states

Figure 3: The *Wasteless* logo

Teaching young children not only affects the future behaviour of the upcoming consumer generation, but often reaches the adult members of the family as well. Therefore, *Wasteless* has high priority of awareness raising on food waste prevention among primary school children through a complex school program developed for this purpose. Recently, our expert team elaborated an educational material composed of a book with students' and teachers' edition, and a workbook. In total we delivered 274 450 pieces to 2666 primary schools of all the three editions. Interactive and playful presentation slides and short animations were designed for primary school teachers as the part of this program (Figure 4). We hope that step-by-step we will be able to tackle the awareness of youngsters and thus develop a long term conscious standard of behaviour that might contribute to their future 'wasteless' habits.

In the frame of awareness raising, we put great emphasis on media appearances. This activity is primarily connected to the dissemination of our outcomes. According to our experiences so far, the media has been highly sensitive with the issue. We also operate a website and social media (Facebook, Instagram). Via these online platforms, educational videos, infographics, news and quiz games are released regularly (Figure 5). Since 2016, the communication elements of *Wasteless* reached 60 million consumers in Hungary (an average person could meet the messages of the programme about six times already).
In the field of food waste reduction, Nébih's project *Wasteless* pays special attention to supporting the stakeholders of the food value chain.
The so-called *"Az* Élelmiszer Érték*"* *(Food is Value)*, established by the cooperation of the Ministry of Agriculture and the Hungarian Food Bank Association is the most important reconciliation forum in the field of food waste reduction, covering the entire sector. Several companies, institutions and organisations – including Nébih - have joined to the initiative. The main objective

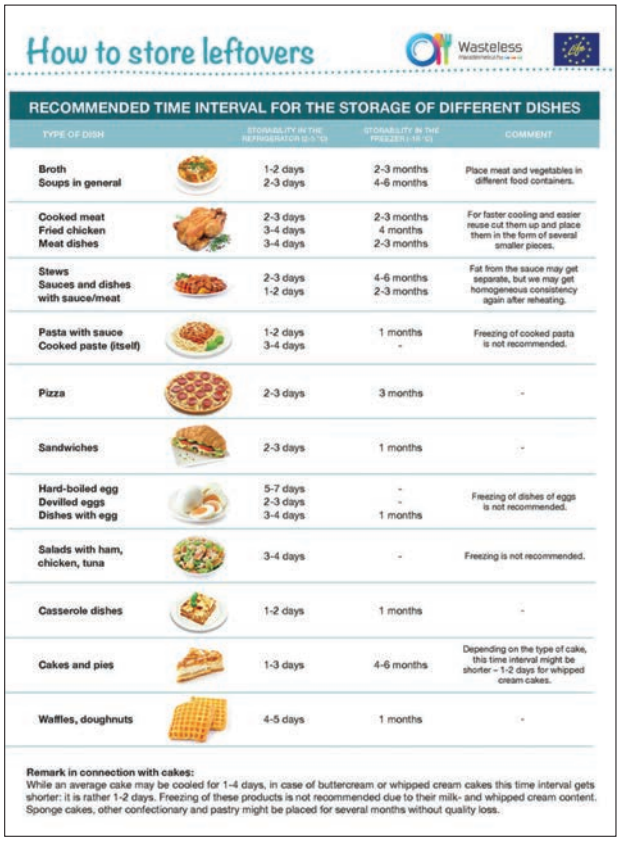

Figure 5: *Wasteless* educational infographic on how to store leftovers (Source: www.maradeknelkul.hu)

Figure 4: Interactive lesson of *Wasteless* (Source: www.maradeknelkul.hu)

is food waste measurement and broad awareness raising.
We must point out, that when it is about food waste management, some of the apparently appropriate solutions might pose a risk to the consumers, and helping intention can be more harmful if we do not meet the requirements of food safety and hygiene. Therefore, we have to keep the balance between food safety and food waste management (Kasza et al. 2018). In the frame of our communication campaign we always pay particular attention to food safety and we implement all our waste prevention activities in such a

spirit. In *Wasteless*, four professional working groups of the campaign have published four guide books that can serve food business operators and consumers to prevent or reduce food waste. Experts from the four work packages have sought possible solutions to the challenges of the hospitality, retail, industry and civil sectors, summarizing good practices that have already been identified, tried or applied worldwide. These solutions include the development of a food waste monitoring and measurement system, the communication about shelf life or the issue of donation.

The guide books, as well as the educational materials and other information packages can be found on the website of the campaign: http://maradeknelkul.hu/en

As a recognition of the efficiency of *Wasteless* campaign, the EU Commission decided to organise the LIFE FOOD WASTE Platform Meeting Conference in Hungary in 2018, and invited Nébih to be hosting the event, which was opened by the speeches of EU Commissioner for Maritime Affairs and Fisheries and the EU Commissioner for Health and Food Safety.

Besides *Wasteless*, there are several other awareness raising programs around Europe, some of them having more than a decade of history. In the followings we describe some, which might be interesting to get more familiar with the topic of food wastage. *WRAP* in the UK works with several stakeholders in order to accelerate the move to a resource-efficient economy. They cooperate with organisations in the food and drink industry to reduce food waste and thus create economic and environmental value. Between 2012 and 2016, *FUSIONS* was running as a consortium with 21 project partners from 13 countries. They endeavoured to work towards a sustainable Europe. The project contributed to the harmonisation of food waste monitoring, and the development of a common Food Waste Policy for the EU. The *REFRESH* campaign works with stakeholders in four pilot countries (Spain, Germany, Hungary and the Netherlands). Their activities include developing strategic agreements to reduce food waste, elaborating policy recommendations and developing technological innovations to contribute to the highest resource-efficiency. With five Central European partner countries, *#reducefoodwaste* network aims to find best techniques for food waste prevention and management. Their goal is implemented by four working groups specified to each level of the entire value chain (production, processing, trade, consumers). Another initiative form the UK is the *Love food hate waste* campaign. They primarily address consumers by promoting simple and easily adaptable food wastage reduction practices for home application. The so-called *Every Crumb Counts* initiative strives to work towards preventing food waste and to promote a life-cycle approach. The joint initiative involves several stakeholders along Europe's food supply chain. In the frame of the project they intend to tackle the awareness of consumers, and thus contribute to halving EU food waste by 2020.

Future

In European law, policy makers established the legislative basis of the circular and bio mass based economy (Kürthy et al. 2019). Besides that, more and more stakeholders are engaged in sustainability, environmental protection and fossil energy exploitation. The Sustainable Development Goal 12.3 of the United Nations targeted to halve per capita food waste by 2030. For this purpose, EU countries have undertaken stable commitment. In 2015, the European Commission issued the Circular Economy Package and an Action Plan, including all of the sectors of interest (from production, through processing and consumption, until waste management). The objective of the Package is to stimulate the efficient use of resources and to support Europe's transition towards a circular economy.

CONCLUSION

In our paper we aimed to present a brief overview about the current situation of food waste generation, legislation and initiatives for prevention. The numbers demonstrated that we are facing a serious problem, and communication should be addressed to every stakeholder along the entire food chain. Relevant legislative basis has been established on European level and several awareness raising and prevention campaigns are running, thus policy makers, scientists, communication and authority experts might be able to carry out significant changes. Still, long term behavioural impact of these campaigns is challenging, therefore it is essential to put more emphasis on the awareness raising of children.

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URBAN HEDGEHOGS *(ERINACEUS ROUMANICUS)* IN BUDAPEST: LIVE OR LET DIE

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ABSTRACT

The Northern White-breasted Hedgehog *(Erinaceus roumanicus)* is a common species in Hungary occurring throughout the country. It has been increased its population sizes in urban environments but also, it is one of the most common mammalian road fatalities in Europe. The observation of a widespread and relatively frequent species often means a non-executable task for the experts. The WildWatcher Programme started in September 2009 aimed to involve the public in this activity provides a huge amount of valuable data and plays a significant educational role. The Programme focuses on 18 species/taxon group. The Hedgehog is the most frequently observed species of the Programme. In this study, we focused on data recorded within the administrative borders of Budapest metropolis. We used traffic intensity data of Budapest roads from the road traffic database of the strategic noise map (renewed in 2018) to apply GIS analysis of road kill frequencies in the road segments. The most dangerous period for the Hedgehog was April, May and July but June is also a dangerous month of the year in Budapest. Road segments where live Hedgehogs were observed had lower traffic than road segments where killed individuals were recorded after sunset but not in day-time. Less intensive traffic of vehicle type II (small tracks, short buses and motorbikes) has been detected in the roads where observations have been made on live Hedgehog individuals than the average traffic of these vehicles. These results do not mean that the vehicles in this category primarily threaten these animals but the roads that are used by these vehicles intensively are the most unfavourable in this point of view. It is hard to find the direct connections between the features of these roads and the high Hedgehog road kill probability but this information can be used to find the most dangerous road segments in Budapest.

keywords: urban wildlife, volunteers, road kill, metropolis, distribution, Hungarian Biodiversity Monitoring System, Web 2.0.

INTODUCTION

The Northern White-breasted Hedgehog *(Erinaceus roumanicus)* is a common but protected species in Hungary occurring throughout the country. Beside of specific studies on selected Hedgehog populations no countrywide survey on distribution of this species was evaluated. Because no other Hedgehog species is living in this region and identification of the species is very easy, this species is a perfect target for citizen science based approach (Cohn 2008) on distribution data collecting programme (Vadonleső Group 2019, Williams et al. 2015, Williams et al. 2018). On the other hand, one of the highly effective instruments of sensitization to the living nature is a deeper social involvement into the practical nature conservation's work (Dimitrakopoulos et al. 2010).

WildWatcher Programme was set off in the frame of the Hungarian Biodiversity Monitoring System in 2009 (Takács 2010, Váczi et al. 2012). The WildWatcher initiative has a dual aim from the beginnings. On the one hand, it aimed to involve wide range of the human society into the practical nature-conservation work to raising public awareness and improving environmental education. On the other hand, it targeted to collect data of the nature-conservation status of Hungarian ecosystems through controlled assessment of some carefully selected plant and animal species (Vadonles Group 2019). More

Figure 1: Road killed Hedgehog on the road of Budapest (Photo: András Attila Takács)

than 15% of its records are from Budapest metropolis in WildWatcher database. The Hedgehog is one of the favourite species in the programme.

There are predictions that by 2050, two-third of human world population will be living in urban areas (Toy & Sezen 2018). Although cities only account for approximately 3% of the Earth's surface, they are often located at the focus of important ecosystem junctions or in the middle of high biodiversity areas (Zari 2018). Conservation of biodiversity of urban areas is getting more and more important topic. In spite of this, shortage of information on urban habitats, and a lack of species occurrence data are often cited as major problems of describing biodiversity status of urban landscapes (Li et al. 2019).

There are many aspects of urban areas that are beneficial for wildlife. Examples of these effects collected by Pettett et al. (2017) was low numbers of natural predators, the availability of supplementary food and altered physical conditions, such as higher temperatures due to urban heat islands. Many species, especially food generalists with high human tolerance and with fast adaptation potential as Hedgehog species have been increased their population sizes in urban environments (Williams et al. 2018).

Contrary to these favourable effects, urban environment is often detrimental to wildlife too. It causes habitat loss and fragmentation, but also road mortality, as direct effect (Rautio 2014). Hedgehogs are one of the mammalians that most commonly have road fatalities (Mikov & Georgiev 2018, Rautio 2014) (Fig 1). Differences in traffic of roads can pose different danger to free living Hedgehogs of a city (Gruychev 2018).

Conservation of protected animals in a metropolis is often a difficult task. Movement of urbanized species as Hedgehogs is practically out of human control (Dowding et al. 2010). To have a chance to decrease road mortality it is important to be able to detect hot spots or even hot segments of roads in a metropolis. Based on this knowledge the road-maintainers can make decisions to avoid high number of road mortality events in the case of Hedgehog individuals.

MATERIAL AND METHODS

For data notification in the WildWatcher Programme's website (Vadonleső Group et al. 2019) the following information is required from volunteers. The spatial localisation of data has to be marked on a Google Map-based map up to a few meters accuracy. Besides, a short data form has to be filled including mandatory questions such as the date, the number and the status (alive, road-killed, died by other reason or remains) of the observed hedgehog individual and optional fields (time of the day, story of the observation, age: adult or juvenile, township, and photos were taken or not) are also appeared in the case of this species. Every record is reviewed by the expert who is responsible for the species. Locality, timing of observation, valid email address and any other speciality of the species are checked when validating the records one by one. The validated records are periodically imported to the Hungarian Nature Conservation Information System (in Hungarian: TIR), where they are labelled as "data source: WildWatcher". Subsequently, after further verification and weighting by the type of the data source, the data stored in this database can support the nature conservation authority's decisions, the management regulations and interventions, the national and international reporting obligations and the species protection work.

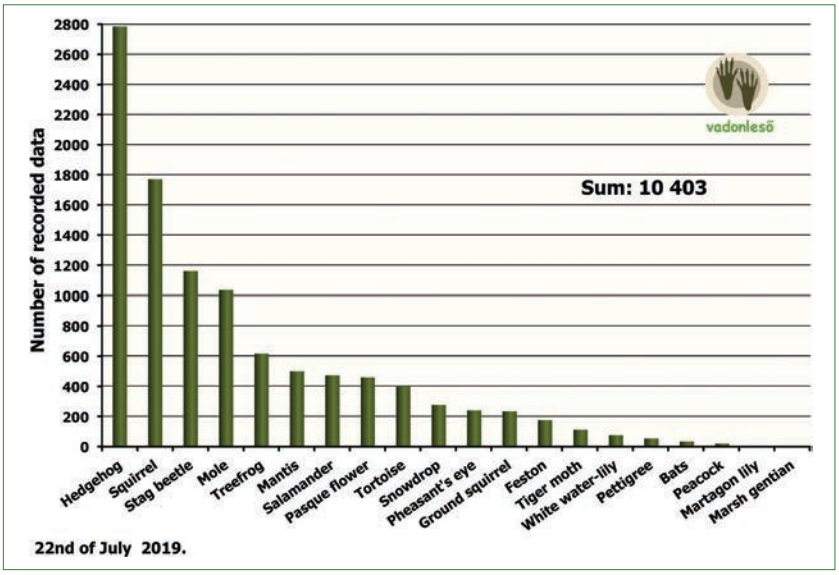


Figure 2: The number of recorded occurrences of the species in WildWatcher Programme

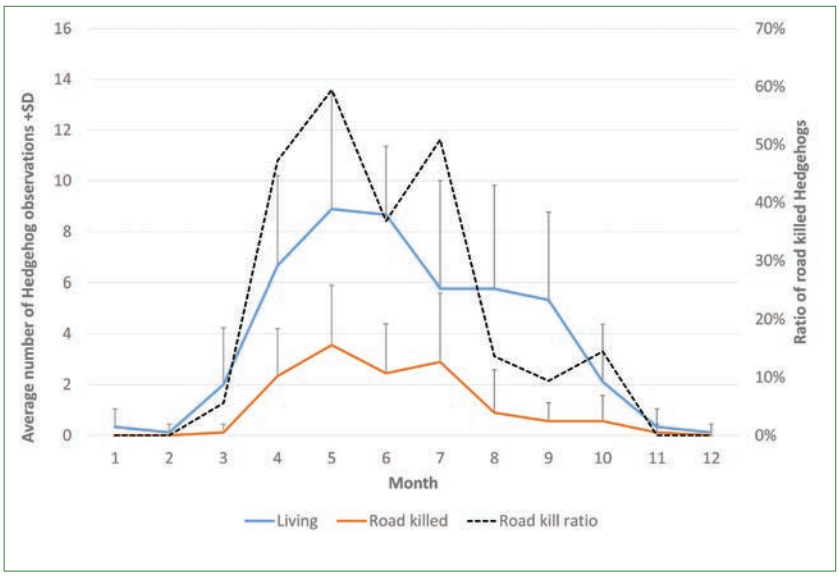


Figure 3: Yearly activity pattern of Hedgehog based on volunteer's observations. Higher road kill ratio means more dangerous periods of the year in Budapest.

In this work we mainly focused on data recorded within the administrative boundaries of Budapest using a safety buffer of 50 meters. All Hedgehog occurrence data were recorded between 1st of September 2009 and 22nd of July 2019. We used traffic intensity data of Budapest roads from the road traffic database of the strategic noise map (renewed in 2018) to analyse roadkill frequencies in the road segments.

Only validated data were used for the analysis. Analyses and statistics were made in a Microsoft Excel spreadsheet and maps were compiled using ArcGIS 10.6.1., based on data recorded between 1st of September 2009 and 22nd of July 2019.

RESULTS

There were about 2 800 volunteers provided more than ten thousand (10 403) record of data during the closely ten years of the operation period of the WildWatcher Programme. 26.7% of all records (2 781) referred to the Hedgehog which is the highest ratio among the species included in the programme (Fig 2.).

29.7 % (827) of all Hedgehog observations were reported on road killed individuals, 1.9 % (52) on dead animals due to any other reasons and the remained 68.4% on live individuals. 70.2 % of the Hedgehog observations were reported from township areas and 76.8 % (1 499) of these were on live animals and 21.3 % (416) were on road killed

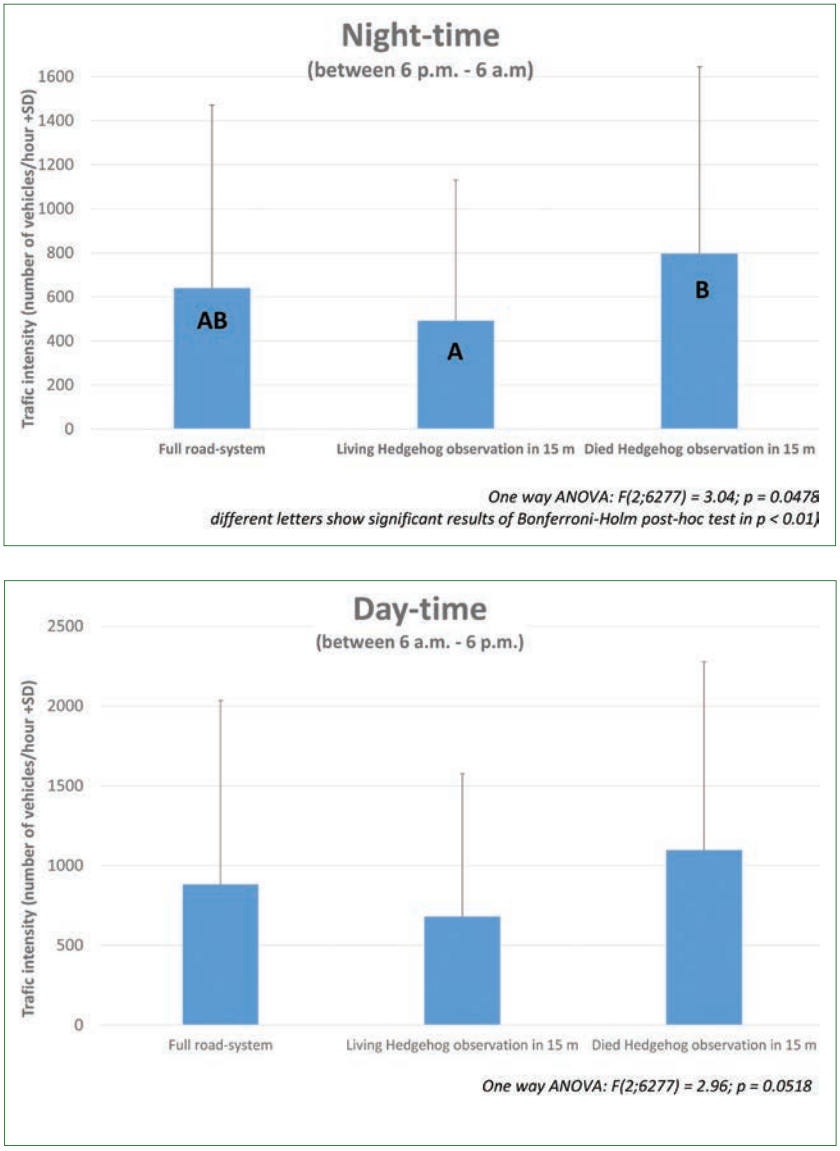


Figure 4: Traffic intensity on the roads with live and dead Hedgehog observations a) in night-time and b) in day-time.

individuals. 49.5 % (403) of Hedgehog observations were recorded outside township area were on live animals and 50.5 % (411) were on road killed individuals.

28.8 % (802) of all Hedgehog observations were reported from Budapest with 79.8 % (640) of observations on live individuals, 18.6 % on road killed individuals and 1.6 % on died by any other reasons.

The most dangerous periods for the Hedgehog with the highest road kill ratios were April, May and July but June is also a dangerous month of the year in Budapest (Fig 3.).

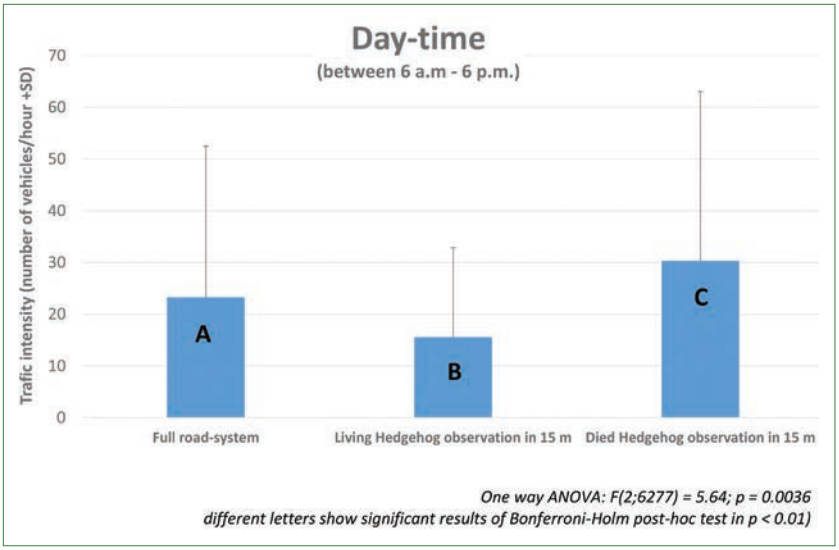
10.9 % (70) of the observations on live Hedgehogs in Budapest were overlap with 72 road segments – using 15 meters safety buffer – from all of the road segments (6 101) in Budapest. It is 67.8 % (101) of the observations in 107 road segments in the case of road killed individuals in Budapest which is significantly higher than in the case of living individuals ($Chi^2 = 65.61$; $df = 1$; $p < 0.0001$).

Road segments where live Hedgehog observations were made had lower traffic than where killed individuals were recorded after sunset (one way ANOVA: $F(2;6277) = 3.04$; $p = 0.0478$; Bonferroni-Holm post-hoc test) but not in day-time (one way ANOVA: $F(2;6277) = 2.96$; $p = 0.0518$, Fig. 4 a and b).

Less intensive traffic of vehicle type II (small tracks, short buses and motorbikes) has been detected in the roads where observations have been made on live Hedgehog individuals than the average traffic of these vehicles in day-time. In contrast, more intensive traffic of vehicle type II has been detected in the roads where observations have been made on dead Hedgehog individuals than the average traffic of these vehicles in day-time. (One way ANOVA: $F(2;6277) = 5.64$; $p = 0.0036$; Bonferroni-Holm post-hoc test, Fig 5a.). The same tendency has been detected in night-time but significant difference has been found in the case of dead Hedgehog observations only (One way ANOVA: $F(2;6277) = 4.37$; $p = 0.0127$; Bonferroni-Holm post-hoc test, Fig 5b.).

DISCUSSION AND CONCLUSIONS

Analysing the number of voluneers' records on the different species or taxon groups shows that animals – first of all mammals – are on the first row because they are much popular and easy to meet them (Vadonleső Group 2019). From the beginning of WildWatcher Programme the Northern White-breasted Hedgehog is the most popular species from all. The Hedgehogs are well known, often but not commonly visible around the close surrounds of the people. The interactions between humans and the Hedgehogs are not rare, they can be fed and sometimes need to be rescued from danger. It seems that the observations give high impression to the observer to be remembered. High amount of good quality records makes it possible to use the data for



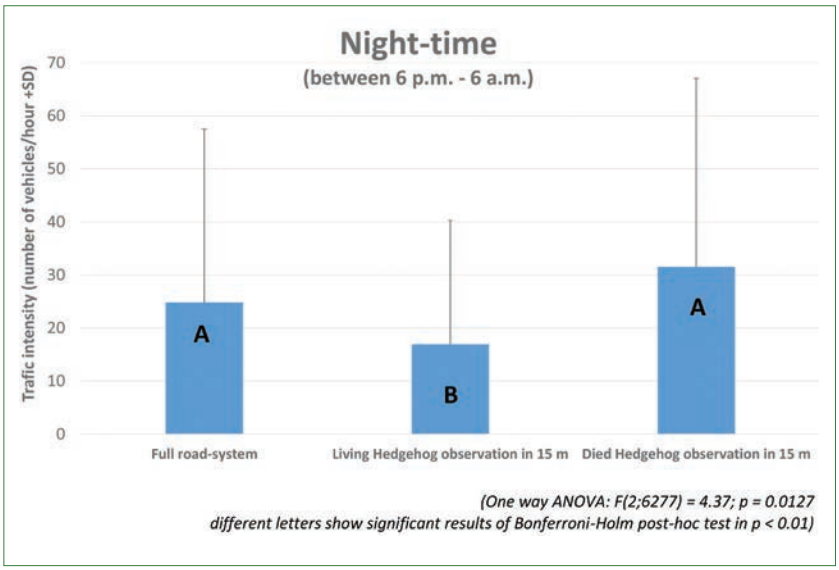


Figure 5: Traffic intensity of vehicles type II on the roads with live and dead Hedgehog observations a) in day-time and b) in night-time.

further analysis and focus on a metropolitan Hedgehog population. High number of Hedgehog observations in Budapest compared to other regions mostly depends on higher number of citizens and higher volunteer activity in the capital city.

High record ratio of road killed Hedgehogs is a sad indication but does not means that every third animals are surely killed on the roads. Not even means that countryside would be less dangerous and Budapest is the most safety place for them to live in. Road killed bodies of the animals stay in place for longer time, which gives much more chance to observe them compared to the live and actively moving nocturnal individuals. There are much more people walking around the streets and parks of Budapest than outside the township at night-time. This phenomena cause that the ratio of road killed animals are so different in Budapest than in countryside. Therefore, it is not possible to use our observation data to detect the real ratio of road killed animals but it can be used to compare how the roads and different types of city structure effect road killing chance inside Budapest. Other studies suggest an idea that Hedgehogs can occur outside their distribution area or in higher densities where normally food-limitation would be presented. Urban areas have both positive and negative influences on wildlife. For terrestrial mammals, one of the principal problems is the risk associated with moving through the environment while foraging (Dowding et al. 2010).

From the knowledge on defensive behaviour of Hedgehogs it is expected that this species is highly vulnerable on the roads. The evolutionary fixed roll up behaviour is a perfect answer to raptors attack but it is very often lethal against a running vehicle. It is not surprising that high number of road killed Hedgehog individuals can be found on the roads. The vehicle traffic in some areas can be a significant factor for the Hedgehog mortality (Mikov & Georgiev 2018).

The ratio of road killed animals was higher in the spring and mid-summer period in Budapest which was the same in the case of country-wide data of Hungary (Vadonles Group 2019) and in a closely related Hedgehog species *(E. europaeus)* in Ireland (Haigh et al. 2014). In their reproductive period Hedgehogs move higher distances and show higher activity than in other parts of the year (Rautio 2014). Higher activity and less vigilance can be the reason for higher ratio of road kill events (Mikov & Georgiev 2018). Weaning of young animals happens in mid-summer. The inexperienced juveniles often fall victim to fast moving vehicles in this period. As they getting older and have more experience probability of road kill events is getting lower and lower. Rautio (2014) found that adult females are also in high danger after weaning when they expand their territory to find enough food before hibernation.

Hedgehogs are mainly nocturnal animals (Pavlovi & Savić 2016), Dowding et al. (2010) found that their activity peak appeared after midnight. It means that

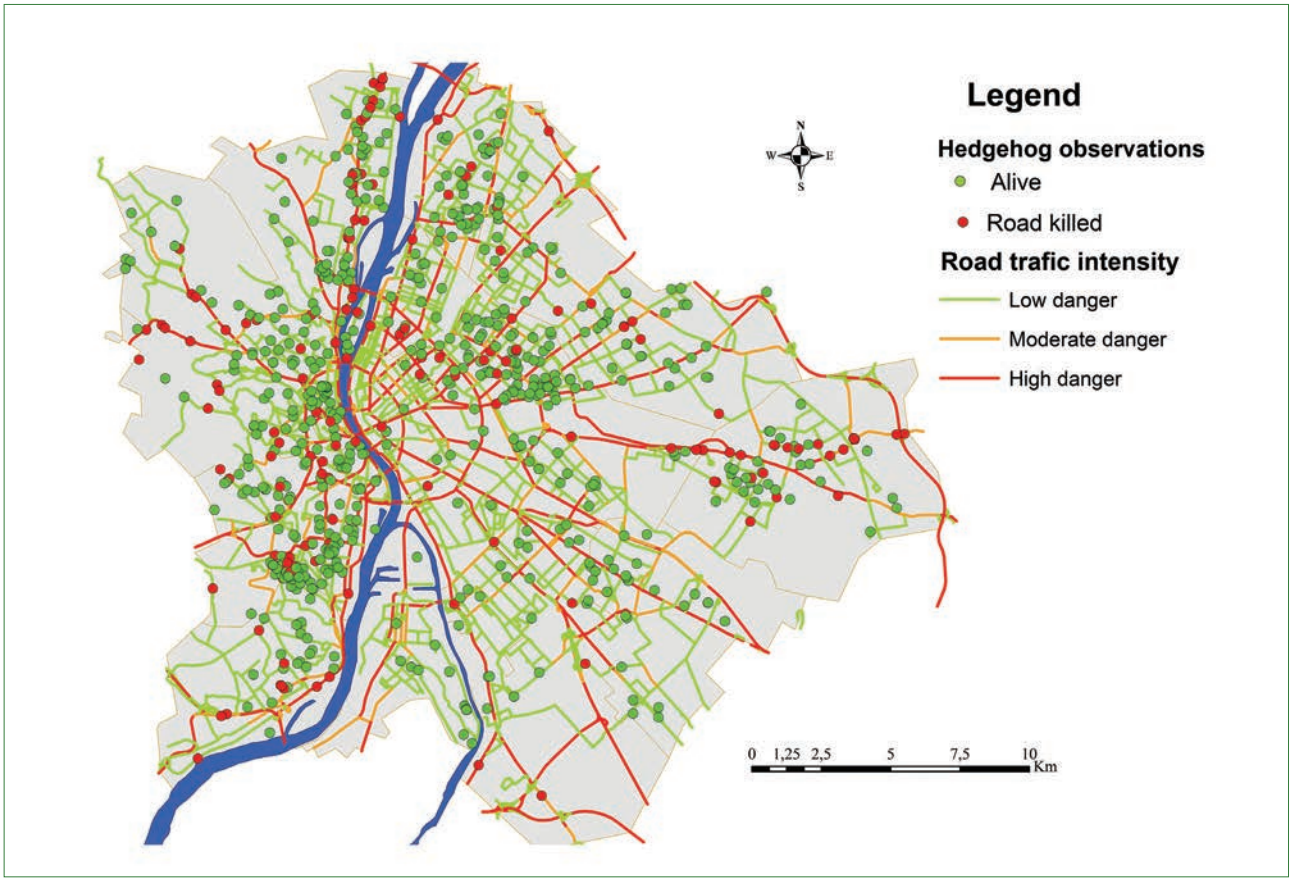


Figure 6: Roads with different categories of danger for Hedgehog road kill.

most of their movements are happening during night-time. Probability of road killing is higher in night-time because of increased activity and decreased visibility. Roads with higher night-time traffic are more dangerous for Hedgehogs than lower ones, but the relationship was not very strong: there was no difference between the average traffic intensity and traffic intensity on roads where live or dead Hedgehog observations had been registered. Tendency was the same in day-time but no significant differences have appeared at all. It has to be taken into consideration that in contrast to the cases of dead animals, the observations on live Hedgehogs are incidental around roads. Hedgehogs tend to avoid roads with heavy traffic, at least in lucky cases. Our results show that this relationship was much stronger in the case of the vehicle type II, which is the group of small tracks, short buses and motorbikes. The effect was the strongest in the case of day-time traffic intensity. This result does not mean that the vehicles in this category cause the most mortality events but the roads that are used by these vehicles intensively are the most unfavourable in this point of view.

It is hard to find the direct connections between the features of these roads and the high Hedgehog road kill probability but this information can be used to find the most dangerous road segments in Budapest (Fig 6). For this analysis, additional information is also needed to be able to select those road segments which has preferred environment around them by Hedgehogs. After all of this, roads of Budapest can be categorized to different levels of danger for the protected Hedgehogs. In the case of roads with the highest level of danger traffic signs that warn about small mammals and an increased use of speed bumps, or "sleeping policemen" can be used (Rautio 2014) to reduce traffic mortality of this species.

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