of spruce tree in studied stands was calculated using dendrometric variables, allometric relationship and stand structure data.
Statistical evaluation of biomass was conducted in the STATISTICA software (STATISTICA Cz 12, StatSoft, Inc.). The confidence interval was set at 95%. Normality and homogeneity of data was examined using the Shapiro-Wilk test. As results of the Shapiro-Wilk test for normality and variance and Barttlet conformity test showed the non-normality of collected data, nonparametric Kruskal-Wallis test was used.

Results

The biggest spruce mortality from the first measurement to a total of 2000 trees per hectare was found on the stand Hruba jedle, where spruce represented more that 30% of the stand - mortality was almost 60% in this stand (Fig. 1). From the moment of reaching the number of 2000 trees ha^{-1} to the present day, mortality was the lowest on this site. However, it should be noted that the total number of trees in the initial measurement was higher when compared to other sites, and up to 100%. From the total number of individuals of 2000 trees ha^{-1} to the present state, the highest mortality of spruce - nearly 50% was on the site of Klepačov, where the $\%_{spruce}$ was 2% (Fig. 2). Although spruce mortality seemed to be high, the total $\%_{spruce}$ on this site increased up to 6%, as other tree species mortality was higher than of spruce itself. Conversely, a downward trend in the $\%_{spruce}$ was found on the site of Smrk, where spruce mortality was higher than that of other species. Starting from the $\%_{spruce}$ about 50%, its admixture dropped in present state to less than 30%.
Total aboveground biomass of spruce showed statistically significant differences, particularly between the second and other forest vegetation zones (Fig. 3). For five-year-old stands differences are apparent in all stands, especially in these with $\%_{spruce}$ under 30%, where spruce biomass was up to 270% lower in the second FVZ than in the third FVZ and 300% than in the fourth FVZ. In older stands these differences were less prominent, and spruce biomass was lower in the second FVZ more than 60% when compared to third and fourth FVZ. Branch biomass of average spruce (Fig. 4) was different in FVZ in younger stands only rarely – only in five-year-old stands with 31-60% of $\%_{spruce}$. In older stands the difference was found between the second FVZ and others, in stands with $\%_{spruce}$ over 61% and up to 50%. Needle biomass of average spruce (Fig. 4) was different in five-year-old stands with $\%_{spruce}$ under 60% and was the lowest always in the second FVZ. In older stands (15 and 25 year-old), the difference was found between the second and other FVZ, in stands with $\%_{spruce}$ over 61%.

Discussion

Increased mortality of spruce trees observed at higher $\%_{spruce}$ in the stands could be caused by impaired adaptation of spruce to environmental conditions in lower forest vegetation zones (Brosinger and Östreicher 2009; Spiecker 2000). Growth of spruce trees at lower $\%_{spruce}$ in the stand is usually enhanced by other tree species. This hypothesis was confirmed by Rothe and Binkley (2001). Suppressed individuals which grow under the main canopy, stagnate in growth and gradually die off, while growth of intermediate and dominant ones is supported by the surrounding trees. This model was described for example by Thiele et al. (2017) and Rio et al (2016). During silvicultural treatments, well growing spruce individuals are left in the stand at the expense of other species and thereby representation of spruce in the stand increases (Pretzsch, Biber 2015). Contrarily, if the initial representation of spruce in a stand is high, during silvicultural treatments mostly spruce trees, that are weaker

than other tree species, are harvested, or they naturally die off under main canopy due to insufficient insulation. Thus, the mortality of spruce in stands with high initial $\%_{spruce}$ increases with stand development, while its representation in the stand in older age gradually decreases.

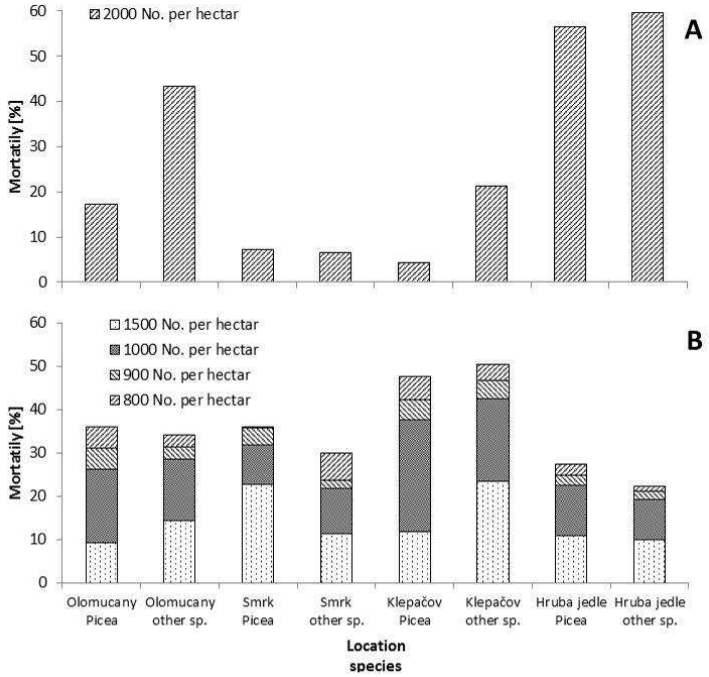

Fig. 1: Mortality in the older stands. A - Mortality from first measurement to 2000 number tree per hectar; B - Mortality from 1500 number trees per hectar.

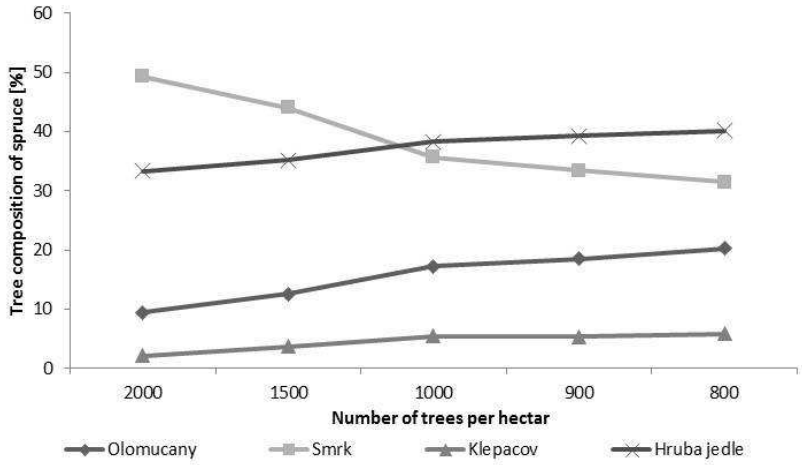

Fig. 2: Tree composition fo Norway spruce from 2000 No. per hectar to 800 No. per hectar.

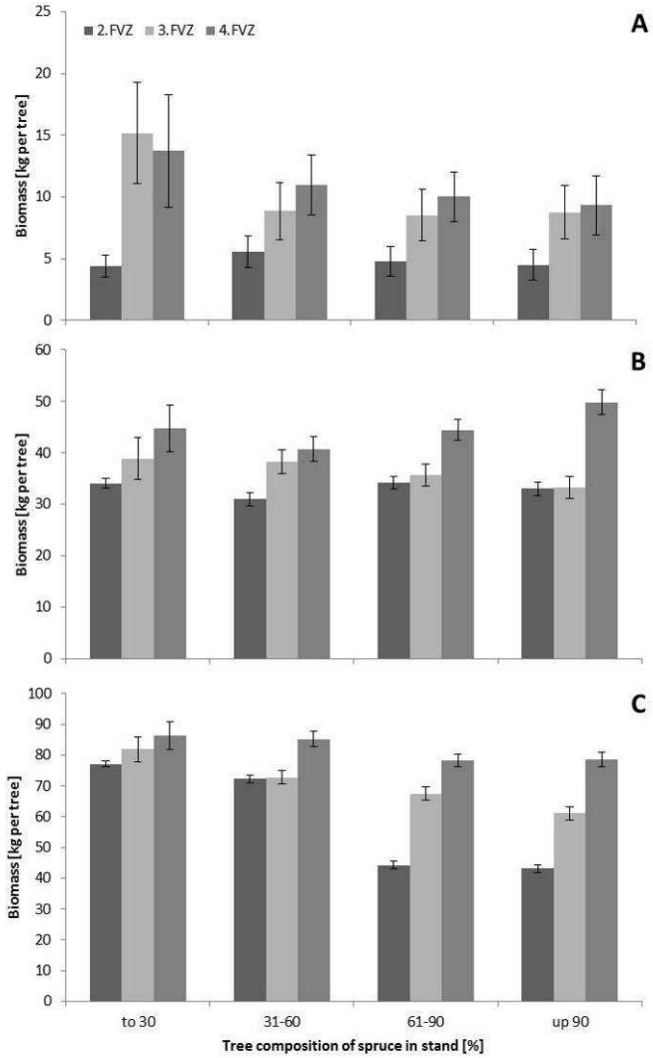

Fig. 3: Total aboveground biomass per tree. A - Total aboveground biomass per tree in 5 years old spruce; B - Total aboveground biomass per tree in 15 years old spruce; C - Total aboveground biomass per tree in 25 years old spruce. Whiskers denote standard deviations.

Our results of spruce biomass development confirmed the hypothesis of Cotta (1828), who suggested higher productivity of mixed forests than monocultures. These results are also in agreement with studies of Frivold and Frank (2002) or Kelty (1992). On the contrary, they opposed to the theory of Hartig (1804), Kennel (1965) or Spellmann (1996) who described lower production of mixed stands compared to monocultures. However, all these authors used data from the stands with best growing conditions for Norway spruce and did not consider sites outside of spruce ecological optimum.

Conclusions

In order to utilize forest non-production functions using mixed stands with Norway spruce in suburban forests at lower altitudes, professional silvicultural treatments are necessary. Spruce mortality in mixed stands in lower forest vegetation zones depended on the initial representation of this species in a stand structure. It was found that in stands with initial $\%_{spruce}$ about 10% or less, spruce trees mortality is lower in lower forest vegetation zones than in stands with spruce representation over 30% under similar environmental conditions. In the case of stands with initial $\%_{spruce}$ around 10%, spruce can reach even 30% of $\%_{spruce}$ in mature age. We found significant differences in spruce biomass in five-year-old stands at almost all of the observed $\%_{spruce}$ stand groups when comparing the second FVZ and other vegetation zones. In the case of 15-year-old stands there was almost no difference in spruce biomass. In the case of 25-year-old stands, spruce biomass was significantly lower in the second FVZ when initial $\%_{spruce}$ was over 61%. These results were probably influenced by silvicultural treatments that were carried out in the stands in time period between five and fifteen years of age when smaller trees were removed, and therefore differences in biomass production in the 15-year-old stands were less evident, while the stands at the age of 25 years began to show the tree development without the impact of silvicultural treatments. It can be assumed that in the further development of stands, the differences in biomass production between the second and fourth FVZ in the stands with $\%_{spruce}$ over 61% will be more and more pronounced.

References

Babst F, Poulter B, Trouet V, Tan K, Neuwirth B, Wilson R, Carrer M, Grabner M, Tegel W, Levanič T, Panayotov M, Urbinati C, Bouriaud O, Ciais P, Frank D, (2013): Site- and species-specific responses of forest growth to climate across the European continent. Global Ecol. Biogeogr. 22, 706–717pp.

Brosinger F, Östreicher S, (2009): Die Fichte im Walden, In: LWF (Ed.), Fichtenwälder Im Klimawandel. 11-15pp.

Cotta von H, (1828): AnweisungzumWaldbau. ArnoldischeBuchhandlung, Dresden, Leipzig.

Frivold LH, Frank J, (2002): Growth of mixed birch-coniferous stands in relation to pure coniferous stands at similar sites in south-eastern Norway. Scan J For Res 17:139–149pp.

Hartig GL, (1804): Anweisung zur Taxation und Beschreibung der Forste. Gießen und Darmstadt, bey Georg Friedrich Heyer.

Hladnik D, Pirnat J, (2011): Urban forestry- Linking naturalness and amenity: The case of Ljubljana, Slovenia. Urban Forestry & urban Greening 10:105-112pp.

Hooper DU, Chapin III FS, Ewel JJ, Hector A, Inchausti P, Lavorel S, Lawton JH, Lodge DM, Loreau M, Naeem S, Schmid B, Setälä H, Symstad AJ, Vandermeer J, Wardle DA, (2005): Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecol. Monogr. 75, 3–35pp.

Kadavý J, Kneifl M, Knott R, (2015): Tree quality and forest structure changes in the first stage of conversion of high forest into coppice-with-standards. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis 63 (5): 1485-1491 p.

Kelty MJ, (1992): Comparative productivity of monocultures and mixed stands. In: Kelty MJ, Larson BC, Oliver CD (eds). The ecology and silviculture of mixed-species forests. Kluwer, Dordrecht, 125–141pp.

Kelty MJ, (2006): The role of species mixtures in plantation forestry. For. Ecol. Manage. 233, 195–204pp.

Kennedy JJ, Dombeck MP, Koch NE, (1998): Values, beliefs and management of public forests in the Western world at the close of the twentieth centruy. Unasylva 49(192):16-26pp.
Kennel R, (1965): Untersuchungenüberdie Leistung von Fichte und Bucheim Reinund Mischbestand. Allg. Forst. Jagdztg. 136: 149– 161, 173–189pp.
Konijnendijk CC, 2008. Adapting forestry to urban demands – role of communication in urban forestry in Europe. Landscape and Urban Planing 52:89-100pp.
Lindén M, (2003): Increment and Yield in Mixed stands with Norway spruce in Southern Sweden. ISSN: 1401-6230, ISBN: 91-576-6344-0
Otto HJ, Stadtnahe Wälder-kann die Forsttwirtschaft sich noch verständlich machen? Forst und Holz 53(1):19-22pp.
Pretzsch H, Biber P, (2015): Tree species mixing can increase maximum stand density. Canadian Journal of Forest Research 46(10):1179-1193pp.
Rio M, Pretzsch H, Alberdi I, Bielak K, Bravo F, Brunner A, Condes S, Ducey MJ, Fonseca T, von Lupke N, Pach M, Peric S, Perot T, Souidi Z, Spathelf P, Sterba H, Tijardovic M, Tome M, Vallet P, Bravo-Oviedo A, (2016): European Journal of Forest Research 135(1):23-49pp.
Rothe A., Binkley D. (2001): Nutritional interactions in mixed species forests: a synthesis. Canadian Journal of Forest Research 31 (11). Pp. 1855-1870.
Spellmann H, (1996): Leistungund Windstabilität von Fichten-BuchenMischbeständen.
Spiecker H, (2000): Growth of Norway Spruce (Picea abies [L.] Karst.) under Changing Environmental Conditions in Europe, In: Klimo E, Hager H, Kulhavý J, (Eds.), Spruce Monocultures in Central Europe – Problems and Prospects, EFI Proceedings. European Forest Institute. 11-26pp.
Thiele JC, Nuske RS, Ahrends B, Paferov O, Albert M, Staupendahl K, Junghans U, Jansen M, Saborowski J, (2017): Climate change impact assessment – A simulation experiment with Norway spruce for a forest district in Central Europe. Ecological Modelling 346:30-47pp.

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Souhrn

Využití mimoprodukčních funkcí kultivací smrku v příměstských lesích v nižších nadmořských výškách vyžaduje speciálních pěstebních opatření. Úmrtnost smrků ve smíšených lesních porostech nižších vegetačních stupňů závisí na počtu jedinců původně vysazených. Bylo zjištěno, že mortalita smrků v porostech s procentuálním zastoupením smrku 10 % a nižší byla úmrtnost nižší než v porostech se zastoupením smrku nad 30 %. Porosty s počátečním zastoupením smrku do 10 % mohou vést ke zvýšení zastoupení této dřeviny až na 30 % v dospělých porostech.
Zjistili jsme významné rozdíly v biomase smrku v pětiletých porostech ve všech skupinách procent smrků, zejména pak mezi druhým FVZ a ostatními. Žádné rozdíly byly zaznamenány u patnáctiletých porostů. V případě dvacetipětiletých porostů byla biomasa smrku nižší než ve druhém FVZ a procentuální zastoupení smrku vyšší než 61 %. Výsledky byly pravděpodobně ovlivněny pěstebními zásahy, které byly provedeny v porostech ve věku mezi pěti až patnácti roky, kdy byly odstraněni slabší

jedinci. Z toho důvodu nebyl zaznamenán rozdíl v patnáctiletých porostech, zatímco u dvacetipětiletých porostů se začal projevovat dopad vývoj stromu bez vlivu pěstebních zásahů. Lze předpokládat, že v dalším vývoji porostů budou stále výraznější rozdíly v produkci biomasy mezi druhou a čtvrtou FVZ v porostech s výskytem smrku nad 61 %.

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USING OF SUCCULENT PLANTS FOR SLOPE STABILIZATION

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Abstract
The highway network in the Czech Republic is often built in the not too favourable conditions for subsequent greening areas along the highways. It is increasingly important to implement new ways of greening, which will help us solve this problem, because of this reason. One of the possible solutions is to spray fragments of succulent plants, together with other supporting materials, which help to fix a plants on a slopes and their subsequent development. It can to achieve to vegetate on unfavourable rocky substrates and create a contiguous vegetation. The vegetation helps to firm the problematic subsoil and prevents of an erosion. This method has been used successfully on some sections of the highways in the Czech Republic, mainly in the South Bohemia of the Czech Republic, where there are already a few years later to see positive results. The main finding is the fact that this way of greening helps to fix a slopes of highways, and for significantly lower cost than other types of fixation of a slopes with stony structure soil.

Key words: fragments of succulents, erosion, highways, slope stabilization, rocky friable soil

Introduction

Construction of highways and roads is due to the growing trend of automobile transport an essential theme, to which it is necessary to hold attention. Motorway in hilly terrain are often lined with long slopes, which are covered by grass vegetation for the most parts with a smaller proportion of plantings of trees and shrubs. Become an integral part of the landscape in which we live. Features of the vegetation is not only landscape-aesthetic effect, but also hygienic, soil-protective and microclimatic features.

Nowadays, more and more grass growing slopes and other ways of strengthening slopes, where are not optimal conditions for the development of classic grass cover. Take into account of the particular safety and economic demands, but also the subsequent maintenance requirements.

Since the 1980s. It has been planted trees and shrubs more often on the slopes. The reason was to create a vegetation, which will allow the reinforcement of slopes with a minimum of maintenance in adulthood. However today, shows increasing maintenance costs associated with the cutting down of trees and thinning. In addition on the rocky crumbly substrates are almost impossible to carry out such a amenity planting. It is one of the main reasons why they are in the construction of new section of highways and rather preferred to grassy-herbal accompanying area, where there is a smaller proportion of tree species.

On rocky crumbly substrates is the problem to keep the crop involved lawn against driving. Water and wind erosion, which is a common problem in newly built roads and highways is one of the basic problems. Otherwise to the development of erosion furrows, leaching of organic particles from the soil and the silting of the riverbed at the foot of the slope. Such a situation may lead to fall all over the slope. Nowadays there are more possibilities of solutions for the fixation of the slopes. However there

are still the effort to strengthen slopes using vegetation. In that reason it is trying out new options for greening on the extreme habitats with rocky crumbly soil. That are the reason to spray fragments of succulent plants on the slopes, which can also work in such extreme conditions as a continuous vegetation without major problems. The greening has even landscape-aesthetic function, but also the function of stabilization of the slope against erosion.

Fig. 1: Classic grass slope

Fig. 2: The slope planting with the cuttings of succulents and grass-herbal seeds

Materials and methods

The accompanying vegetation communications offers space for planting crops with a predominance of bright sub-succulent plants. Such growths are not sown in abundance, having regard to the initial costs of seeds and cuttings of plants and also because of the higher risk of erosion on the artificial slopes. This method is testing sequentially for reasons of ignorance of the technology and the subsequent behavior

of the plants at extreme habitats. Is also missing the experience of realization of companies and designers themselves.
In the implementation of hydraulic application and seeding are done with cuttings of succulent plants, particularly the genus Sedum, accompanied herbs and grasses that prevent low sow and germinate quickly, reducing the risk of intense vegetation uptake until function take on the flowering herbs and succulents. The varieties grass types according to the applicable norms should be Czech origin. Another condition is their drought. Setting up the lawn, as well as green areas with succulents and herbs builds on the groundwork (according to TKP 4), where it is further dealt with the issue of soil preparation before the sowing. Reinforcement of the slopes concerned belongs to the technical standards.
The vegetation is establish by hydraulic application and seeding. It is a hydraulic kind of seeding of the areas hard to reach, with worse quality of the underlying soils or steep slopes with an incline of 60 °. It can be supplemented with the use of natural geotextiles, special constructions and other anti-erosion measures. Those applied mixture helps stabilize the soil and the seed to the full involvement of the shade. The blend is designed with regard to layout and is enriched with substances that accelerate the germination and growth, fertilizer, water, organic substrate and erosion control additives. Erosion control additives are important ingredients to protect against wind and spray water and anchor the seed and organic substrate on unstable soils, or on places where it is needed the increased erosion control protection. For the determination of the formula hydraulic application and seeding is valid ČSN 83 9041. Use of soil improvers and new types of anti-erosion additive is given in Appendix 1 to the TP 99. Here is a rule that the slopes should be before the founding of without weeds. Spraying on is carried out in such a manner to avoid disruption of the surface protective layer and washing away growing cuttings. Optimum time of sowing is from mid-March to mid-October, when are the best conditions for a successful growing cuttings and their subsequent development. The implementation of hydraulic application and seeding is excluded in July and August, when can be overheating and drying out of the slopes and as a result it may happened a failure to develop succulents. With exceptions, and especially considering the weather conditions, it is possible to perform hydraulic application and seeding with increased risk until the middle of November. It is necessary to hold the current climatic conditions, because in heavy rain and wind could hydraulic application and seeding failed. Hydraulic application and seeding´s compound is composed of a mixture of herbs and grasses for extreme conditions on a rock with seed rate to 10 g/m2 and a mixture of the cuttings of the genus Sedum with seed rate up to 30 g/m2. In addition to the mixture of seeds and cuttings are adding organic fertilizer, a primer, paper-straw mulch material and water. Aftercare and passing the following areas are based on the valid technical standards.
An example of increasing biodiversity in the landscape is nature greening on the slopes of a stretch of Highway D3, and in the length several kilometers away, where they were planting in 2013 such successfully applied. From this successful effort is an attempt to use this method for other newly constructed highways. Succulents are chosen deliberately to the mixture because they are able to vegetate on extreme rocky substrates with high temperatures and often even pollution. Therefore it shows as an appropriate choice in places where there is minimal or no soil for the growth of the classical lawns, shrubs, or trees.

Results

With newly built roads with mostly rocky slopes of the friable ground is recommended to use this method of downloading the accompanying vegetation use. Grass-herbal stands succulents tested in southern Bohemia are already fully stable and so we can say that this way of greening of the problematic slopes is a good solution. It's not just the unique link of sowing grasses and herbs with a planting of Sedum cuttings, but above all about the institutions successful attempt to reduce the cost of implementation without having to enrichment with humus and also by reducing the cost of maintenance as follows based surfaces.

The proposed ways of establishing of succulent vegetation mixed with grasses and herbs lead to diverse species and biomass poorer vegetation. In addition to their own savings in the maintenance of vegetation are also offers an additional positive effect, and that strengthening the ecological functions of the landscape and support biodiversity. Belts of vegetation in the area-based communications are beneficial both for the protection of nature and of course rates may compensate for the loss of natural values in the Territories concerned the construction of a road and the subsequent operation. Succulent plantings containing some grasses and herbs allow you to stabilize the problematic slopes and increase operational safety on the roads. After the engagement and the creation of a contiguous vegetation prevent erosion due to water penetrating roots and the emergence of a potential landslide erosion furrows, or slip the slope. Their rooting allowed to fix the individual particles of the subsoil and their replacement during the wind erosion. Finally green areas allows the slopes where other methods could not use. By acting on the aesthetic and ecological value of the landscape.

For several years, are planting low-productive grass-herbal mixtures in European countries (e.g. in the UK, Austria and Spain). The aim is to create a species-rich mixture that is respond the technical conditions of grass growing (especially quick involvement of vegetation to prevent erosion), and their seeding would be possible on the slopes with extreme habitat conditions and rocky soil.

Discussion

Promoting new technologies in the creation of the accompanying vegetation along the highway has a great importance for the further development. This method is not necessary even desirable to use of all the areas of the slopes and certainly doesn't mean restricting the planting of shrubs and trees which have their place in the landscape, as well as human modified habitats, such as highway undoubtedly are. It shows opinions that the problematic slopes of highways, where it is not possible to perform lawn and planting trees should stay, as they are only using the security of the slopes of the views of the transport. This approach can also have negative consequences. Less stable slopes with problematic subsoil is difficult to stabilize soil and prevent subsequent erosion. If it succeeds, it is a very expensive process. In addition, at some sections of these slopes are several hundred feet long, so there would be to create a kind of lunar landscapes, where time to time snap airstrikes of weeds. From the perspective of landscape and ecological is preferable green these slopes, if site conditions permit.

The problem may be the realization that requires high-quality execution and accurate compliance with seed mixtures and the entire course of the procedure. Nowadays this trend may reduce the costs of implementation, which is developed on the realization companies. Non-observance of technological procedures and possible confusion or change in crop mixture for the cheapest, could lead to failed realization that would not fulfil true purpose.

The current practice of grass growing of the slopes is not very satisfactory, both in terms of maintenance, as well as from the perspective of stabilization of slopes against erosion. Presented technology of the creation stands with grass-herbal succulent species would help saves considerable costs for the subsequent maintenance of complicated habitats.

References

Anonymus (2004): Vysazování a ošetřování silniční vegetace. Technické podmínky. Ministerstvo dopravy. Odbor pozemních komunikací. TP 99, dodatek 1.
Coffin A. W. (2007): From roadkill to road ekology: A review of the ecological effects of roads. University of Florida. Journal of Transport Geography 15.
Forman R. T. T., Alexander L. E. (1998): Roads and their major ecological effects. Harvard University Graduate School of Design, Cambridge, Massachusetts. Annu. Rev. Ecol. Syst. 1998.
Kavka B., Šindelářová J. (1978): Funkce zeleně v životním prostředí. Praha: Státní zemědělské nakladatelství.
Bulíř P., Škorpík M. (1987): Rozptýlená zeleň v krajině: Typologie, rozšíření, navrhování, zakládání a pěstování. Praha: Sempra, 1987.

Souhrn

Budování dálnic je často prováděno na skalnatých podložích nebo extrémně nevhodných stanovištích pro následné ozelenění. Takové plochy se skalnatým podložím, které nemá pevnou strukturu a téměř žádnou humusovou vrstvu, mohou být problematické z hlediska fixace svahu a předcházení vodní erozi. Ani pro klasické výsevy travnatých ploch, případně výsadby keřů a stromů, nejsou takové plochy vhodné. Na svazích, kde je skalnaté drolivé podloží se ukázalo jako vhodné řešení využití hydroosevu řízků sukulentních rostlin společně s travobylinnými druhy. Především trávy s rychlejším klíčením zamezí intenzivnímu zaplevelování svahů do doby, než sukulenty a byliny vytvoří souvislý porost. Takový porost napomáhá zpevňovat problematické podloží a brání případné erozi. Náklady při zakládání jsou vyšší z důvodu ceny směsi rostlin, na druhou stranu se výrazně snižují náklady na následnou údržbu takto osetých ploch. Tato metoda byla úspěšně použita na úsecích dálnice D3 z Prahy do Českých Budějovic v České republice, kde je již porost plně zapojený.

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VALIDATION OF THE METHOD USED FOR THE VISITOR MONITORING: A CASE STUDY CONDUCTED IN THE LOCALITY OF HRADSKÁ

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Abstract
A visitor monitoring is one of the tools which help to ensure quality and suitable management of the respective area. This paper concentrates on such visitor monitoring during which the visitors are counted automatically using a field counting device, namely a pyroelectric sensor. The aim of this paper is to conduct a regression analysis of the data collected in the selected locality so as to determine whether the pyroelectric sensor provides relevant information. The validation was performed in a chosen area – the locality of Hradská (one of forest roads of the Training Forest Enterprise Masaryk Forest Křtiny, Czech Republic). Two data sets gained during the first week of the visitor monitoring at a single locality have been compared. The first set includes data gained by the automatic monitoring using the pyro sensor, the other set contains data gained by means of manual counting by students of the FFWT. Two directions of visitors' flows were monitored. The data were statistically processed using the ADSTAT programme. Results of the regression analysis show that the results of the visitor monitoring carried out using a pyrosensor differ just slightly from those gained by manual counting.

Key words: recreation, forest roads, management, regression analysis, pyrosenzor

Introduction

Over the last decades, tourism has been the crucial factor in both social and economic regional development as for example Lama and Sattar (2002), Hall, Mitchell, Roberts (2003), Banaš (2006), Michopoulou and Buhalis (2013) have mentioned. No more is tourism just a disturbing element; the society has started appreciating the benefits which the use of the territory brings to tourists, at the regional level in particular. From the economic point of view, these benefits are represented by financial funds which each tourist leaves in the region. On the other hand, the increasing number of tourists brings the necessity to establish so-called visitor attendance management. Basic tasks of the visitor attendance management should mainly include an elimination of negative effects related to tourism and establishing a sustainable use of the respective territory. More detailed data about the recreational use of the territory are required so that they can be subjected to further research. Using the results together with scientific and sociologic knowledge enables an ecologically and economically sustainable management of the researched territory. To establish a quality and suitable management, first it is necessary to find out who is going to use the territory and how, as well as to which extent the environment is influenced by tourism. This is can be done by means of a complex visitor monitoring. Generally, the aim of the complex visitor monitoring is to provide basic information about the number of visitors together with information about the time-variability of the visitor attendance (Zahradník, Banaš and Jirásková, 2012). Various methods of visitor monitoring may be employed to gain information about who uses the territory and to which extent. Examples can be found in Muhar, Arngerger and Brandenburg (2005) who dealt with various methods, which they

divided into direct and indirect ones. These days, visitor monitoring is mainly employed in the protected areas (see e.g. Cole, 1989; Manning, 2002; Muhar, Arngerger and Brandenburg, 2005; Beunen, Regneurs and Jaarsma, 2008; Wolf, Hagenloh and Croft, 2012); however, its methods may be used to monitor visitor attendance in forests, too. Usually, the complex visitor monitoring comprises three parts. These are uninterrupted counting of visitors by an automated device, regular physical counting, and a questionnaire survey.

This paper concentrates on visitor monitoring using automated visitor counting by means of a counting device which allows for gaining basic information about the number of visitors and their characterization. Nowadays, four basic technologies are used to count visitors to a territory automatically. Firstly, it is the use of stepping pressure sensors which act on the basis of a change in pressure; secondly, there are thermal sensors (pyroelectric sensors or pyrosensors) working on the principle of detecting a body temperature, then there are magnetic counters which use magnetic response and, finally, optical sensors may be used which act on the principle of interrupting an optical beam (see e.g. Zahradník, Banaš, Jirásková, 2012). Within a project by the Internal Grant Agency (IGA) of the Faculty of Forestry and Wood Technology (FFWT) of Mendel University in Brno (MENDELU), a visitor monitoring was conducted at selected forest roads in the Training Forest Enterprise of Masaryk Forest Křtiny (TFE Křtiny) in 2015. This monitoring was conducted using a pyro sensor. Since the authors of the project want to use this method when dealing with another project of IGA, too, it was necessary to find out whether the pyro sensor is a reliable tool and can be employed in further research. The aim of this paper is to carry out a regression analysis of the data from the selected locality to find out whether the pyroelectric sensor provides relevant information.

Materials and methods

The Hradská forest road was selected as the interest area. This forest road lies in the territory of the TFE Křtiny. The visitor monitoring was conducted by means of automated counting using a thermal sensor. In the target counting profile, it was complemented with physical calibration counting carried out by the students of the FFWT of MENDELU. The visitor monitoring in this locality was carried out from July to October 2015. The data from the first month of measuring were selected for the case study, specifically; the overall data from the first week of measuring were used. The data were gained within the time interval of 9 a.m. – 5 p.m. Two directions of visitor flows were monitored: IN and OUT. The input data for the analysis is shown in Table 1.

The Table 1 lists two sets of data. The first set includes data gained by the automatic monitoring using the pyrosensor, the other set contains data gained by means of manual counting by students of the FFWT.

For the purpose of this paper, the following H_0 hypothesis was posed: The data gained by means of the pyroelectric sensor provide relevant information. This hypothesis is going to be tested statistically by means of a linear regression analysis. Namely, validation of the new analytical method will be used to clarify the function between the dependent variable and the independent variable. A regression model will be created using the method of least squares (LSM), which is commonly used for creating models (see Meloun, Militký, 2012).

The International Vocabulary of Metrology defines validation as the process of verification that the specific requirements are adequate for the intended use (TNI 01 0115). Most often, validation is used in various laboratories (see Riley, Rosanske, 1996), but it can also be employed to verify models in economics (see e.g. Fagiolo,

Moneta and Windrum, 2007). The process of validation as well as of regression diagnostics has been described by Meloun, Militký (2012). The procedure is divided into several steps: model designing, a preliminary data analysis, a parameter estimate, basic statistical characteristics, and a regression diagnostics – this contains a critique of the data, the model and the method, a so-called regression triplet, creation of a more precise model and assessment of its quality. The data were statistically processed using the ADSTAT programme 1.25.

Results

Firstly, a linear regression model was designed for the validation of the model. The parameters of the model were determined using the least square method where *y* (the counter) is the dependent variable and *x* (manual counting) is the independent variable. Thus the formula for this model can be $y = \beta_0 + \beta_1 x$. For this model, the null hypothesis is going to be tested ($H0: \beta_0 = 0; \beta_1 = 1$), i.e. we assume the ideal condition of a line where both the slope and the intercept are zero. Preliminary data analysis is given in Table 2. The Pearson correlation coefficient (R) shows a significant correlation between the variables *y* and *x*.

A parameter estimation was made using the standard least square method to determine the regression parameters of the intercept β_0 and the slope β_1. The analysis was significant at the level of alfa = 0.05. Using the Student's *t*-test, it was determined that the absolute member (intercept) can be considered statistically insignificant. The slope, on the other hand, is statistically significant since *t* is bigger than the quantile of the Student's distribution $t_{crit} = 2.074$. Statement is documented by Table 3.

Basic statistical characteristics of regression are shown in Table 4.

It follows from Table 4 that according to the Pearson's R, the designed linear model is statistically significant. The value of the coefficient of determination shows the ratio of the experimental data points which fit the given model. In this case, 78.49% of the data points fit.

Tab. 1: The input data of analysis; n = 24

Time	Direct	Counting by students	Pyrosenzor
1st hour	IN	36	27
	OUT	36	9
	TOTAL	49	36
2nd hour	IN	22	23
	OUT	11	11
	TOTAL	33	34
3rd hour	IN	56	45
	OUT	22	15
	TOTAL	78	60
4th hour	IN	23	15
	OUT	23	16
	TOTAL	46	31
5th hour	IN	14	16
	OUT	20	21
	TOTAL	34	37
6th hour	IN	18	14
	OUT	17	15
	TOTAL	35	29
7th hour	IN	16	10
	OUT	39	24
	TOTAL	55	34
8th hour	IN	16	10
	OUT	29	28
	TOTAL	45	38

Tab. 2: Preliminary data analysis

Variable	Average	Standard Deviation	Paired correlation coefficient	Calculated level of significance
y	24.917	12.840	1.000	------
x	32.208	16.395	0.886	0.000

Tab. 3: Estimates of regression parameters

Parameter	Estimation	Standard Deviation	Sample t-test (t_{crit})	H_0 is	Level of significance
b_0	2.5686	2.7867	0.9217	accepted	0.367
b_1	0.6939	0.0774	8.9601	rejected	0.000

Tab. 4: Basic statistical characteristics of regression

Statistical characteristics of regression	Value
The multiple correlation coefficient (R)	0.88595
The coefficient of determination (R^2)	0.78491
The predicted correlation coefficient (Rp)	0.86869
Mean square error of prediction (MEP)	38.7680
Akaike information criterion (AIC)	88.6200

Subsequently, a regression diagnostics is going to be made which comprises a so-called regression triplet. This triplet is contained of three parts – a critique of the data, of the model, and of the method.
Within the data critique, the plausibility of the parameter estimate of β_0 and β_1 shall be determined. It is necessary to identify influential data points and to exclude strong outliers so as to determine a best-fitted model. In the ADSTAT program, the graph of regression model (Figure 1) and the analysis of classical residues (Figure 2) were compiled.
An analysis of classic residuals is not too reliable and might not indicate outliers. Yet the analysis of classic residuals (residuals versus the predictions) allows for identification of suspicious data points, of a trend, and of heteroscedasticity. Charts of the influential data points can identify the presence of outliers and extremes. To assess the influential data points correctly, it is always necessary to use more charts. In this case were used – Graph of predicted residues (Figure 3), Pregibon graph (Figure 4), Williams graph (Figure 5), McCulloh-Meeter graph (Figure 6) a L-R graph (Figure 7).
The graphical analysis of the influential data points showed that the model contained outliers which had to be eliminated; they were the data points of 2 and 9. These points were identified by all five graphs.
The next step is the critique of the model. Suitability of a model can be assessed based on the course of the model function (see Figure 1). The assumed linear model may be considered suitable, since the linear dependency was kept. The critique of the method or of the fulfilment of basic assumptions of the LSM was done

using the ADSTAT 1.25 programme. Six assumptions were evaluated – see Table 5. The Fisher-Snedecor test proved that the model is significant. The residuals show heteroscedasticity and they are not normally distributed. Estimated parameters of a more precise model show Table 6. Basis characteristics of a more precise model presented Table 7.

The value of the mean quadratic error of prediction (MEP) dropped from the value of 38.768 to the value of 24.586; at the same time, the value of the Akaike information criterion (AIC) dropped too, from the value of 88.620 to the value of 70.376. The decrease in both the values signifies a better quality of the model. Considering the normality of the residuals, the characteristics of the model are better in this respect, too, thanks to the elimination of the outliers – see Table 8.

Finally, the quality of the model was assessed. The more precise model can be formulated as follows: $y = 3.6162(2.4773) + 0{,}6820(0.0753)x$

Since there was a decrease in the deciding criteria of MEP and AIC and, at the same time, both the Pearson's r and the coefficient of determination increased, the specified model can be regarded as of a better quality. The interval parameter estimate of the β_0 intercept is:

$$b_0 - t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_0)} \leq \beta_0 \leq b_0 + t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_0)}$$

$$3.3162 - 2.074 \times 2.4773 \leq \beta_0 \leq 3.3162 + 2.074 \times 2.4773$$

$$-1.8217 \leq \beta_0 \leq 8.4541$$

The interval parameter estimate of the β_1 slope is:

$$b_1 - t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_1)} \leq \beta_1 \leq b_1 + t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_1)}$$

$$0.6820 - 2.074 \times 0.0753 \leq \beta_1 \leq 0.6820 + 2.074 \times 0.0753$$

$$0.5258 \leq \beta_1 \leq 0.8381$$

Tab. 5: Criticism of fulfilment of the basic assumptions of the LSM

Parameter	Value
Fisher-Snedocor significance test of model, F	
Criterion value F	80.284
Table quantile F(1-alpha, m-1, n-m)	4.3009
Conclusion	proposed model is accepted as an important
Counted level of significance	0.000
Scott criterion of multicollinearity, M	
Criterion value M	0.000
Conclusion	proposed model is correct
Cook-Weisberg test of heteroskedasticity, Sf	
Criterion value Sf	121.000
Table quantile, Chi^2 (1-alpha, 1)	3.8415
Conclusion	residues showed heteroscedasticity

Counted level of significance	0.000
Jarque-Berr normality test of residues, L(e)	
Criterion value L(e)	8.5603
Table quantile, Chi^2 (1-alpha, 2)	5.9915
Conclusion	normality is not accepted
Counted level of significance	0.014
Wald test of autocorrelation, Wa	
Criterion value Wa	1.0933
Table quantile, Chi^2 (1-alpha, 1)	3.8415
Conclusion	residues is not autoccorelation
Sign test of residues, Dt	
Criterion value Dt	-1.0436
Table quantile N(1-alpha/2)	1.6449
Conclusion	residues don't show the trend
Counted level of significance	0.148

Tab. 6: Estimated parameters of a more precise model

Parameter	Estimation	Standard Deviation	Sample t-test (t_{crit})	H_0 is	Level of significance
b_0	3,6162	2,4773	1,4323	accepted	0,159
b_1	0,6820	0,0753	9,0517	rejected	0,000

Tab. 7: Basic statistical characteristics of regression

Statistical characteristics of regression	Value
The multiple correlation coefficient (R)	0.89655
The coefficient of determination (R^2)	0.80379
The predicted correlation coefficient (Rp)	0.87401
Mean square error of prediction (MEP)	24.5860
Akaike information criterion (AIC)	70.3760

Tab. 8: Jarque-Berr normality test of residues L(e)

Parameter	Value
Criterion value L(e)	1.0236
Table quantile, Chi^2 (1-alpha, 2)	5.9915
Conclusion	normality is not accepted
Counted level of significance	0.599

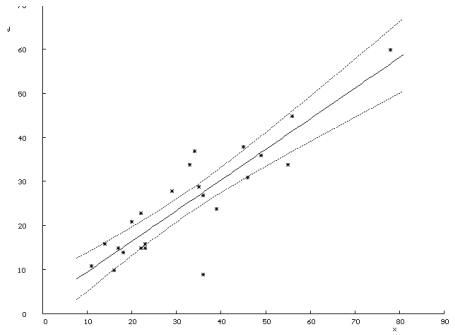

Fig. 1: Graph of regression model

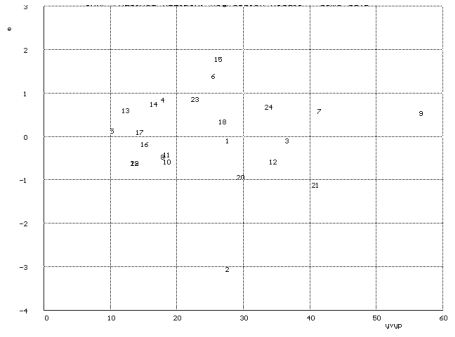

Fig. 2: Analysis of classical residues

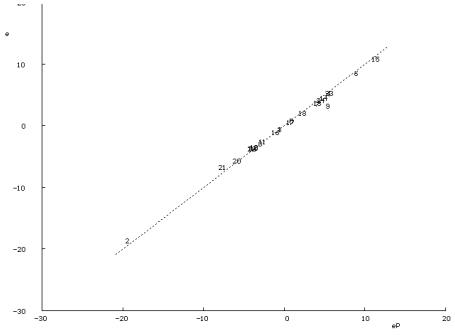

Fig. 3: Graph of predicted residues

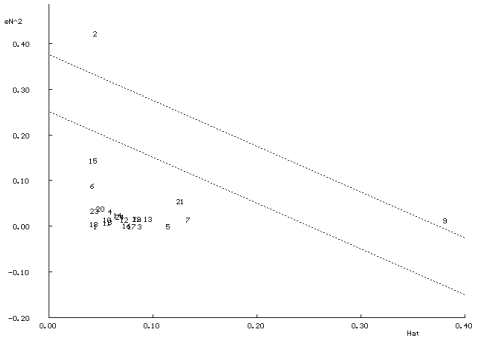

Fig. 4: Pregibon graph

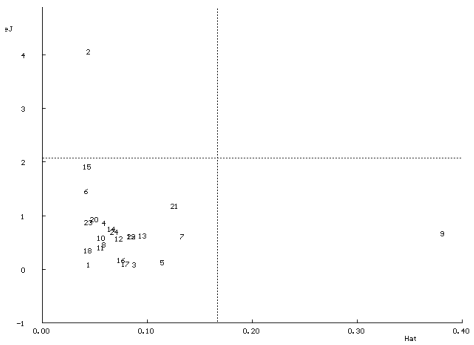

Fig. 5: Williams graph

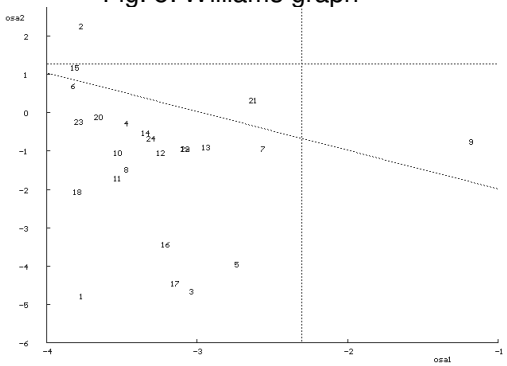

Fig. 6: McCulloh-Meeter graph

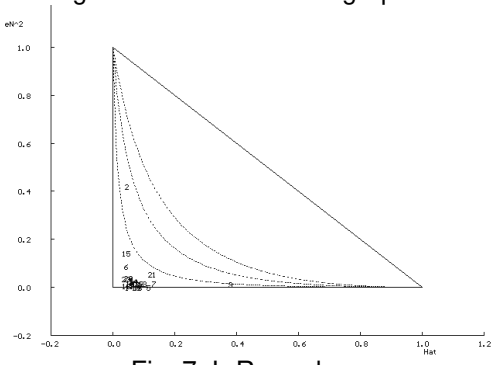

Fig. 7: L-R graph

Discussion and Conclusion

Best-practice visitor-monitoring techniques are crucial for the assessment of tourism-related impacts in natural areas of high conservation value (Wolf, Hagenloh and Croft, 2012). An analysis of the validation of the analytical method was done; its aim was to evaluate whether a pyroelectric sensor would provide relevant information and, consequently, if it could replace manual counting of visitors to the territory. The original regression model contained 24 data points. The graphical analysis defined the data points 2 and 9 as outliers and as such, they were eliminated. Consequently, a more precise model was created which showed better characteristics. The interval estimate for the intercept of the final model contained the 0 value; therefore, the intercept may be considered a zero intercept. The interval estimate for the slope did not contain the value of 1; therefore the slope cannot be seen as unitary. With regard to the results, it can be stated that the results of the visitor monitoring with the use of pyro sensors only slightly differ from those of manual counting. Thus, it is possible to claim that employment of a pyrosensor can bring relevant information. The stated hypothesis H_0 can be accepted. The described method may also be used for evaluation of data relevance in any locality of monitoring.

References

Banaš, M. (2006): Sustainable Tourism in European Mountain Protected Areas – report about a project supported by Alfred Toepfer Natural Heritage Scholarship and EUROPARC Federation. 44.

Beunen, R., Regnerus, H.D., Jaarsma, C.F. (2008): Gateway as a means of visitor management in national parks and protected areas. Tourism Management 20: 138-145.

Cole, D.N. (1989): Wilderness Campsite Monitoring Methods: A Sourcebook (General Technical Report, INT-259). Ogden, UT: United States Department of Agriculture Forest Services Intermountain Research Station.

Fagiolo, G., Moneta, A., Windrum, P. (2007): A Critical Guide to Empirical Validation of Agent-Based Models in Economics: Methodologies, Procedures, and Open Problems. Comput Econ 30: 195-226.

Hall, D., Mitchel, M., Roberts, L. (2003): Tourism and the countryside: dynamic relationship In New directions in rural tourism. Aldershort: Ashgate Publishing Ltd.: 3-15.

Lama, W.B., Sattar, N. (2002): Mountain Tourism, and the Conservation of Biological and Cultural Diversity. Thematic Paper for the Bishkek Global Mountain Summit.UNEP.

Manning, R.E. (2002): How Much is Too Much? Carrying Capacity of National Parks and Protected Areas. In Arnberger, A, Brandeburg, C., Muhar, A. (eds.). Monitoring and Management of Visitor Flows in Recreational and Protected Areas. Conference Proceeding. 306-313. Bodenkultur University, Institute for Landscape Architecture and Landscape Management. Vienna.

Meloun, M., Militký, J. (2012): Kompendium statistického zpracování dat. [Compendium of statistical data processing]. Praha: Karolinum Praha. 985.

Michopoulou, E., Buhalis, D. (2013): Information for challenging markets: The case of the accessibility requiring market in the context of tourism. Information & Management 50: 229-239.

Muhar, A., Arnberger, A., Brandeburg, C. (2005): Monitoring of visitor flows and visitor needs as a basic for protected area management. 3rd Symposion of the Hohe

Tauern National Park for Research in Protected Areas. September 15th to 17th, Castle of Kaprun: 153-157.
Riley, C.M., Rosanske, T.W. (eds.). (1996): Development and Validation of Analytical Methods. Elsevier Science Ltd. 352 p.
TNI 01 0115:2009. Mezinárodní metrologický slovník – Základní a všeobecné pojmy a přidružené termíny (VIM). [The International Vocabulary of Metrology]. Wolf, I.D., Hagenloh, G. Groft, D.B. (2012): Visitor monitoring along roads and hiking trails: How to determine usage level in tourist sites. Tourism Management 33(1): 16-28.
Zahradník, D., Banaš, M., Jirásková, E. (2012): Back and Front of Visitor Monitoring – Examples of Good and Less Successful Visitor Monitoring in the Czech Protected Areas. In Fialová, J. (ed.) Public recreation and landscape protection – hand in hand. Conference proceeding. 2nd-4th May, Křtiny: 177-184.

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Souhrn
Pro management jakéhokoli rekreačně využívaného území je důležité zjistit míru stávajícího ovlivnění turismem. Jedním z nástrojů, které napomáhají zajištění kvalitního a vhodného managementu daného území, je v současné době monitoring návštěvnosti. Metody monitoringu návštěvnosti jsou klíčové pro posuzování vlivů souvisejících s cestovním ruchem nejen v chráněných územích. Monitoring návštěvnosti lze provádět mnoha metodami. Příspěvek se zaměřuje na monitoring návštěvnosti pomocí automatického sčítání návštěvníků terénním sčítacím zařízením, konkrétně pyroelektrickým senzorem (pyrosenzorem). V rámci projektu Interní grantové agentury (IGA) Lesnické a dřevařské fakulty Mendelovy univerzity v Brně byl v roce 2015 prováděn monitoring návštěvnosti vybraných lesních cest na Školním lesním podniku Masarykův les Křtiny pomocí tohoto pyrosenzoru. Jelikož tuto metodu chtějí autoři příspěvku využít i pro řešení dalšího projektu IGA bylo třeba zjistit, zda je pyroelektrický senzor spolehlivý a pro další šetření využitelný. Cílem příspěvku je na datech z vybrané lokality pomocí regresní analýzy zjistit, zda pyroelektrický senzor poskytuje relevantní informace. Konkrétně byla použita validace analytické metody. Byly porovnávány dva soubory dat pro jednu lokalitu v souhrnu za první týden monitoringu návštěvnosti v období červenec 2015. První soubor zahrnoval data z automatického monitoringu pyrosenzorem, druhý soubor představoval data získaná ručním sčítáním studenty Lesnické a dřevařské fakulty Mendelovy univerzity v Brně. Sledovány byly dva směry pohybu návštěvníků – IN a OUT. Pro statistické zpracování dat byl využit program ADSTAT 1.25. Původní regresní model zahrnoval 24 bodů. Body 2 a 9 byly z důvodu odlehlosti, což bylo zjištěno především grafickou analýzou, vyloučeny. Byl sestaven zpřesněný model, který vykazoval lepší vlastnosti. Na základě výsledků z regresní analýzy vyplynulo, že výsledky monitoringu návštěvnosti pomocí pyrosenzoru se pouze mírně odlišují od ručního sčítání. Hypotéza stanovená na začátku výzkumu byla přijata. Popsanou metodu lze využít i pro vyhodnocení relevantnosti dan na dalších lokalitách monitoringu.

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VEGETATION OF SELECTED AGRI-ENVIRONMENTAL MEASURES AND THEIR ESTHETIC VALUE IN THE LANDSCAPE

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Abstract
The contribution is focused on vegetation assessments of selected agri-environment measures, bio-belts in this case, and their esthetic value in the landscape. Bio-belts play an important role in the landscape. It performs several functions (for example provision of food to animals or erosion protection) and their appearance may contribute to the variety and diversity of landscapes. Plants growing in bio-belts can significantly affect the aesthetic perception of the entire landscape. The monitored bio-belts are located in the cadastral areas of Žarošice in South Moravian region. The species composition of plants was evaluated according to phytosociological methods. The total species composition and cover of plants were recorded in the field in July 2016. The total number of forty-seven plant species was found on thirty-six study plots in the selected area.

Keywords: plant species, bio-belts, biodiversity, phytosociological methods, Rural Development Programme

Introduction

The problem of reducing biodiversity is considered as one of the major global problems (Nature, 2009). Biodiversity in agriculture is a broad term. It includes all the components which form agroecosystem: species, varieties, breeds, microorganisms on species and ecosystem levels and are necessary to sustain key functions of the agricultural system, its structure and processes (Šarapatka, Niggli, 2008). Agroecosystems are often surrounded by more natural, respectively close to nature ecosystems and in detention of them closely linked. Species diversity of agroecosystem is significantly reduced. Wide range of biomass to them temporarily binds a series of primary consumers (like wild boar *Sus scrofa* or sika deer *Cervus nippon*) and their predators. Current agroecosystems represent a significant reduction in spatial heterogeneity of landscapes, resulting in a a decrease species diversity (Marada et al., 2013). Agri-environmental measures are intended to mitigate the negative impacts of modern agriculture on the environment by providing financial incentives to farmers for adopting farming practices environmentally friendly (Kleijn et al., 2006). Agri-environment measures are designed on the basis of the increasing negative impacts of agricultural production on the valuable habitats and the environment in general. Their aim is being to strengthen the prevention of soil degradation, enhance retention capacity of the soil and landscape. They also have the task of restoring and maintaining valuable habitat on agricultural and forest land in terms of species diversity, increase stability and aesthetic value of the landscape and also enhance functional connections landscape. Agri-environment payments play a key role in supporting the sustainable development of rural areas and respond to the increased demand for environmental services for society (EAGRI, 2014). One of agri-environment measures is support for the creation of bio-belts. A

bio-belt (Figure 1) is defined as a food line field of a width 6–24 meters and a minimum length of 30 meters. Seeds for the establishment of bio-belts comprise of spring cereals, buckwheat (*Fagopyrum esculentum*), millet (*Panicum miliaceum*), forage kale (*Brassica oleracea*) and from seeds of two other plants according to the choice of the bio-belt founder (Rural Development Programme for years 2014–2020). The contribution deals with composition of vegetation of selected bio-belts in terms of its esthetic value in the landscape.

Materials and methods

Characterization of selected area

The monitored areae is located in the cadastral areas of Žarošice and in South Moravian region. The area lies geomorphologically in the complex Žďánický forest. Geological bedrock of the area is formed by unpaved sediments (loess and loess loam) and consolidated sediments (claystone, sandstone). Pedological bedrock is formed by chernozems. The territory is located in phytogeographical district Hustopečská hills. The area of interest lies in Hustopečský bioregion. Area lies in the climatic zone T2 and T4. The climate area T 2 is characterized by long, hot and dry summer, a very short transition period, slightly warm spring and autumn, short, moderately warm, dry to very dry winter with very short duration of snow cover. Climatic area T 4 is characterized by a very long, very hot and very dry summers, the transitional period is very short, with a warm spring and autumn, winter is short, moderately warm and dry to very dry with a very short duration of snow cover (QUITT, 1971).

Characterization of bio-belts

Bio-belts were sown April 1., 2016. Their composition is as follows: *Fagopyrum esculentum*, *Triticum aestivum*, *Panicum miliaceum*, *Lupinus albus*, *Brassica oleracea* and *Phacelia tanacetifolia*. Bio-belts were located on land blocks with the following produced crops: winter rape (*Brassica napus* var. *Arvensis*) and winter wheat (*Triticum aestivum*).

Evaluation of vegetation

Two bio-belts were evaluated in July 2016. Some preparatory works had to be conducted before the field research started. First, it was necessary to search for land blocks on which there are bio-belts. Subsequently, they were searched in LPIS (Public land register) and it was identified where to place phytosociological plot. Depending on the size of bio-belts, five and seven phytosociological plots were recorded. Furthermore, phytosociological plots were recorded on the land block in the vicnicity of bio-belts and at the edge of the land block, where are no bio-belts, as a control. The plot size was 4 m^2. Total cover and list of plant species in plot with particular cover value were recorded in each of the phytosociological plots. Cover was estimated in percentage scale. Species composition of vascular plants and coverage were evaluated in Microsoft Excel. Plant names used in this text follow Kubát et al. (2002). Subsequently, the species were divided into three groups according to their esthetic value.

The groups are as follows:

- HIGH (potential high esthetic value):
    - plant species with conspicuously colourful flowers increasing the esthetic value of bio-belts,
- MEDIUM (potential medium esthetic value):

- plant species with colourful flowers, but of smaller size, smaller flowers, low contrast of flowers of the crop, with spiny stems and leaves, ornamental invasive plants or due to other reasons plants increasing less the aesthetic value in awareness of people,

- LOW (potential low esthetic value):
  - inconspicuous plant species, plant species with featureless flowers (for example grasses) or on the other hand tall expansive plants without ornamental value in bio-belts.

Results

A total of 47 weed species was found during the field research. The following tables (Table 1 and Table 2) show the average cover of individual species on the individual land block and their esthetic values. As the plant species with high esthetic value, were selected following plant species: *Phacelia tanacetifolia* (Figure 2), *Lupinus albus*, *Papaver rhoeas*, *Adonis aestivalis*, *Consolida regalis*, *Vicia cracca* and *Tripleurospermum inodorum*. Winter rape and winter wheat crops were assigned a esthetic value of medium. To plants species in the bio-belts were esthetic value assigned as follows: *Phacelia tanacetifolia* and *Lupinus albus* – high; *Fagopyrum esculentum* and *Triticum aestivum* (spring form) – medium, *Brassica oleracea* and *Panicum miliaceum* – low.

Fig. 1: An example of bio-belts dividing land block
Source: Helena Hanusová, 2016

Fig. 2: Phacelia tanacetifolia found in bio-belt
Source: Helena Hanusová, 2016

Tab. 1: Found plant species on the land block with winter rape

Plant species	Bio-belt	In the vicinity of bio-belt	On the edge of the land block	Esthetic value
	Average coverage			
***Brassica napus* var. *Arvensis* (crop)**	1,5	76	90	medium
Brassica oleracea	4,8	1,5		low
Fagopyrum esculentum	19	2,67		medium
Panicum miliaceum	9,8	2,5		low
***Triticum aestivum* (spring form)**	13,4	5		medium
Phacelia tanacetifolia	20	1,33		**high**
Lupinus albus	2			**high**
Papaver rhoeas	4	3,2	5,4	**high**
Capsella bursa-pastoris	1		1	low
Zea mays	1			low
Atriplex patula	3	1		low
Taraxacum sect. Ruderalia	2			medium
Persicaria lapathifolia	2	5		low
Euphorbia helioscopia		1	1,67	medium
Veronica arvensis		1,33		medium
Viola arvensis		1,5	1	medium
Chenopodium album		3		low
Sinapis arvensis		1		medium
Lamium purpureum			5	medium
Convolvulus arvensis			3	medium
Anagallis arvensis			5	medium
Adonis aestivalis			2	**high**
Lathyrus tuberosus			4	medium
Avena fatua			2	low
Consolida regalis			4,75	**high**
Arrhenatherum elatius			8	low
Dactylis glomerata			4,2	low
Lolium perenne			8,4	low
Galium mollugo			6,67	low
Bromus sterilis			1	low

Vicia cracca			3	**high**
Festuca arundinacea			4	low
Potentilla reptans			2,5	medium
Arctium lappa			1	low
Thlaspi arvense			12	low
Lolium multiflorum			3	low
Achillea millefolium			5,5	medium
Tripleurospermum inodorum			4	**high**
Lotus corniculatus			1	medium
Elytrigia repens			3	low

Discussion

Generically numerous was bio-belts growing on the soil block winter wheat. Two plant species in the bio-belts has been assigned the value "high". It could be recommended to add additional plant species in planting bio-belts, in order to increase their esthetic value. Suitable species that can enhance the esthetic value of bio-belts are: *Centaurea cyanus*, *Helianthus annuus* our even found plant species *Papaver rhoeas* a *Adonis aestivalis*. *Adonis aestivalis* and *Centaurea cyanus* according to the Red List among the rare taxa, which need further attention. Planting of these species would at the same time contributing to their conservation. It could be also recommended planting of *Trifolium pratense* and *Onobrychis viciifolia*. Significantly flowering species also increases the diversity of landscapes.

Esthetic value is associated with a purely subjective approach and it is methodologically difficult to grasp. „Each eye sees beauty elsewhere“ - this sentence Löw a Míchal (2003) describe a subjective approach. According Svobodová (2011) each esthetic evaluation is subjective, but it can be generalized certain features of the landscape, which are considered generally accepted esthetic values.

Conclusion

The total number of forty-seven plant species was found on thirty-six study plots in the selected area. As the plant species with high esthetic value, were selected following plant species: *Phacelia tanacetifolia*, *Lupinus albus*, *Papaver rhoeas*, *Adonis aestivalis*, *Consolida regalis*, *Vicia cracca* and *Tripleurospermum inodorum*. Two plant species in the bio-belts has been assigned the value "high". It could be recommended to add additional plant species in planting bio-belts, in order to increase their esthetic value

Heterogeneous landscape is generally esthetically more valuable. Bio-belts divide large land blocks and so can support mosaicity of natural landscape.

Tab. 2: Found plant species on the land block with winter wheat

Plant species	Bio-belt	In the vicinity of bio-belt	On the edge of the land block	Esthetic value
	Average coverage			
Phacelia tanacetifolia	31,43			**high**
Panicum miliaceum	3,57			low
***Triticum aestivum* (spring form)**	4,86			medium
Brassica oleracea	3,9			low
Fagopyrum esculentum	7,86			medium
Lupinus albus	1			**high**
***Triticum aestivum* (winter form - crop)**	4,67	99,29	75,43	medium
Tripleurospermum inodorum	36,8			**high**
Papaver rhoeas	2			**high**
Thlaspi arvense	2	0,5		low
Atriplex patula	4	1		low
Persicaria lapathifolia	4			low
Viola arvensis	13			medium
Lathyrus tuberosus	3			medium
Veronica arvensis	20			medium
Chenopodium album	4,67			low
Galium aparine		0,75		low
Brassica napus var. Arvensis		0,5	8	medium
Festuca rubra		0,5		low
Avena fatua			40	low
Lolium perenne			5	low
Capsella bursa-pastoris			3,5	low
Elytrigia repens			6	low
Bromus sterilis			8,83	low
Urtica dioica			5,75	low
Taraxacum sect. Ruderalia			1,5	medium
Glechoma hederacea			10	low
Descurainia sophia			5	medium

References
EAGRI, (2017): ©2017. The Rural Development Program 2014-2020. [online]. Available at: http://eagri.cz/public/web/mze/dotace/program-rozvoje-venkova-na-obdobi-2014/. [2017-03-23]. (czech)
Kleijn, D., R. A. Baquero, Y. Clough, M. Díaz, J. Esteban, F. Fernández, D. Gabriel, F. Herzog, A. Holzschuh, R. Jöhl, E. Knop, A. Kruess, E. J. P. Marshall, I. Steffan-Dewenter, T. Tscharntke, J. Verhulst, T. M. West A J. L. Yela. (2006): Mixed biodiversity benefits of agri-environment schemes in five European countries. Ecology Letters.9(3): 243-254.
Kubát, K. a kolektiv. (2002): Key to the flora of the Czech Republic. 1st ed., Praha: Academia. (czech)
Löw, J., Míchal, I. (2003): Landscape character. 1st ed.,Kostelec nad Černými lesy. (czech)
Marada, P., Havlíček Z., Skládanka, J. (2010): Nature and landscape conservation: ecosystem services - a new trend in the agricultural business: [(methodical aid for agricultural practice)].1st ed. Brno: Mendelova univerzita v Brně. (czech)
National Geoportal INSPIRE. ©2017. Map application. Cenia. [online]. Available at:: http://geoportal.gov.cz/web/guest/map. [2017-03-23]. (czech)
Nature.com. ©2009. A safe operating space for humanity. [online]. Available at: http://www.nature.com/nature/journal/v461/n7263/fig_tab/461472a_F1.html [2017-03-23].
Svobodová, K. (2011): Perception of landscape, research and use in strategic planning. Diploma theses. Faculty of Architecture, Czech Technical University, Prague. Institute of Spatial Planning. (czech)SZIF, 2017. ©2017. The Rural Development Program for 2014-2020 version approved by the government on 9. 7. 2014. [online]. [2017-03-23]. Available at:: https://www.szif.cz/cs/prv2014. [2017-03-23]. (czech)
Šarapatka, B., Niggli, U. (2008): Agriculture and landscape: the ways to mutual harmony. 1st ed. Olomouc: Univerzita Palackého v Olomouci.(czech)
Quitt, E. (1971): Climatic regions of Czechoslovakia. Praha: Academia, Studia Geographica 16, GÚ ČSAV v Brně. (czech)

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Souhrn
Příspěvek je zaměřen na posouzení vegetace vybraného agroenvironmentálního opatření, v tomto případě opatření biopásy, a jejich estetické hodnoty v krajině.
Sledované biopásy leží v katastrálním území Žarošice v Jihomoravském kraji. V červnu 2016 byl proveden fytocenologický průzkum, při kterém byly zhotoveny fytocenologické snímky.
Při fytocenologickém snímkování byla zaznamenána celková pokryvnost snímku a pokryvnost jednotlivých druhů rostlin. Na zaznamenaných třiceti šesti fytocenologických snímcích bylo nalezeno čtyřicet sedm druhů rostlin. Jako rostlinné druhy s vysokou estetickou hodnotou, byly vybrány následující: *Phacelia tanacetifolia*, *Lupinus albus*, *Papaver rhoeas*, *Adonis aestivalis*, *Consolida regalis*, *Vicia cracca* a *Tripleurospermum inodorum*.
Biopásy hrají v krajině důležitou roli v krajině a plní několik funkcí (např. zajištění potravy pro zvěř či protierozní ochrana) a jejich vzhled může přispět k rozmanitosti

a pestrosti krajiny. Rostliny rostoucí v biopásu mohou významně ovlivnit estetické vnímání celé krajiny.

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VISITOR MONITORING IN THE TERRITORY OF LESY MĚSTA PÍSKU, LTD. USING FIELD COUNTING DEVICES

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Abstract
Visitor monitoring is one of the tools which help to ensure a quality and suitable management of the respective territory. Within the project of the Internal Grant Agency of the Faculty of Forestry and Wood Technology of Mendel University in Brno, a visitor monitoring was carried out on the selected forest roads in the territory of Lesy města Písku, Ltd. in 2016. The aim of this contribution is to determine specific parameters of the territory, such as the number of visitors, to define the most prominent and required localities and to enable finding the area of the future interest as well as potential financial flows of Lesy města Písku, Ltd. using a visitor monitoring. The visitor monitoring was conducted by means of automated visitor counting using field counting devices, namely pyroelectric sensors. The results concentrate on assessment of the number of visitors depending on the type of users, months of year, days of week, and daytime.

Key words: economics, forestry, forest roads, pyrosenzor, recreation

Introduction

In the long-term view, supporting recreational activities plays a significant role in the policy of regional development which is based on a contemporary developmental theories and tourism theories in the years after the World War II. (Telfer 2002). The recreational use of the territory is very often bound to the term of tourism. Tourism, as well as any other human activity, affects both community and locality where it is actively performed. Although the term impact is often negatively perceived, it is not always detrimental. In fact, tourism can have positive impacts on the respective locality and, in some cases, even a positive effect on the natural environment. (Lück, 2008)

Despite the fact that opinions on impacts of tourism are still rather controversial, it is clear that tourism is the main economic force in the world (Weaver, 2001). The activities of tourism are materialized through economic benefits for the visited area by means of transfer of wealth and investments from the wealthier and more developed areas to the less wealthy and developed ones (Sharpley 2002). Expenditures of the visitors into the target area shall be the main carriers of this transfer, together with the investments in the tourist infrastructures made by enterprises from the areas generating tourists, including all its positive and negative impacts (Williams 2000). An idea to support those activities which are environment-friendly asserted itself quite quickly, mainly with regard to the physical impact of tourism on the environment (Hall, Frost 2009).

Nevertheless, tourism activities have wide variety of impacts on its surrounding in the long-term view. In bibliography, these impacts are usually sorted into three categories: economic impacts (e.g. Gökovali, Bahar 2006; Katircioglu 2009; Lew 2011; Ivanov, Webster 2013; Tang, Abosedra, 2014), environmental impacts (e.g.

Marzano, Dandy 2012; Barros et al. 2013; Oian 2013; Newsome 2014), and socio-cultural impacts (e.g. Daldeniz, Hampton 2013; Thomas et al. 2013). Not only result they often in degradation of both the environment and the local culture, but they also destroy local resources, both directly and indirectly(Williams 2000), which is accompanied with degradation of the sources of tourism itself. Unless this is rectified, the situation can reach a state when the tourists, followed by the tourist enterprises, leave for other localities leaving behind an area and its inhabitants depleted of the sources of their growth (Butler 1980; Williams 2000). Traditionally, this development is considered to be related to the tragedy of commons (Hardin 1968). Fortunately, some groups have already known since 1960s that in the long-term view, a boisterous development of tourism brings more losses than profits (not only from the economic point of view, but from the environmental and cultural in particular). Therefore, public institutions and gradually also enterprises adopt measures to mitigate the negative impacts of visitor attendance in the target areas (Hall, Frost 2009).

A complex monitoring of tourism generally aims to provide basic information about the number of visitors and about the time variability of their visits (within a day, a week, a month of year, and a season) and the spatial distribution of the visitors within the target area (Zahradník et al. 2012). Data about the structure of visitor opinions are also the standard part of the output. Recently, visitor monitoring has been one of the main activities related to tourism conducted by administrations of large protected areas (Bláha 2010; Kala, Salov 2010; Kos 2010).

With the present-day growing standard of technologies, it is possible to use devices specialized in counting various target objects. As a result, almost anything moving can be monitored in field: pedestrians, cyclists, cross-country skiers, motorists, paddlers, etc. Providing the devices are combined suitably, it is possible to distinguish individual types of tourists to the locality reliably and to determine their ratio. A complex visitor monitoring combines uninterrupted counting of visitors by automated field devices (various types according to the requirements on the subjects to be counted) with a regular physical survey and a questionnaire survey (see e.g. Fialová et al. 2014).

Automated field counting using counting devices allows for gaining basic information about the number of tourists. A more advanced (and more expensive) configuration also provides information about types of counted subjects (e.g. distinguishing pedestrians from cyclists) and about the direction of their movement. Nowadays, several basic technologies are used for this purpose. (Zahradník et al. 2012)

Forests are ideal places for tourist activities of various kinds. Thus, forests fulfil their recreational function which is one of the socio-economic functions of ecosystems.

The aim of this contribution is to determine specific parameters of an area (the number of visitors) by means of visitor monitoring, to find the most stressed and desired areas and to help to determine the trend in future interest and potential financial flows of Lesy města Písku. Ltd.

Material and methods

Lesy města Písku, Ltd. (hereinafter referred to as the "Lesy města Písku") is a company founded by the City of Písek in order to manage a forest area of 6,500 ha. The City of Písek is an owner of the company which is responsible to its founder, i.e. to the Council of Písek, for management of the territory. The running of the company is overseen by members of a properly elected supervisory board, too. Management of the forests is divided into 11 areas. Foresters are managed by the forest administration which ensures the overall running of the company. The forest assets

are vast and include the forest stretch of Boudy u Mirotic in the northern part of the district, the forest areas around Dědovice, Lísek, Sloupovny and the mountain complex of Písecké hory at Albrechtice nad Vltavou which is a part of the natural park of the same name. (Lesy města Písku, Ltd. 2016)
Both qualitative and quantitative research methods were employed in the project. Furthermore, information was used from already published results of preceding research carried out by the research team of the Faculty of Forestry and Wood Technology (FFWT) of Mendel University in Brno (Hlaváčková et al. 2015; Hlaváčková, Březina 2016) as well as other teams dealing with a similar topic. The most frequently used forest logging roads were selected for the survey with the aim to monitor the users of the roads in the interest area. Namely, the forest logging roads of Na Flekačkách (the category of 73 6108 – 1L according to the Czech National Standard – CNS) and Amerika (the category of 3L) were chosen.

Fig. 1: A map with marked localities of visitor monitoring at selected roads of Lesy města Písku (1 – Amerika, 2 – Na Flekačkách)

The selection of the specific areas was based on the characteristics of the technology used and on the rules of measured data relevance. Above all, the areas with multiple passing of the same persons were excluded.
The monitoring devices were mounted at the end of June 2016 and the monitoring was carried out till October 2016. At the same time, workers and students of Mendel University carried out a comparative manual calibration counting in the period between 11 – 17 July 2016 at the individual profiles of monitoring.
The automated counters Pyro Box Compact by Eco-counter and Trail Counter by TRAFx were used to monitor the forest road users. These devices are intended for counting all path users (pedestrians, bikers, in-line skaters, etc.) without distinguishing the type of user. The counting works on the principle of measuring differences in temperature of human body and the ambient temperature. With double-sensor counters, it is possible to determine the direction of movement. Being equipped with batteries, the counters are not dependent on an external power supply. Data are saved in a memory in hour-long intervals. Thanks to a flexible mounting system, the counters can be installed on any column or tree trunk. Based on the comparison of the results of manual and automated counting, a so-called calibration coefficient was set for the individual localities. Normally, this ratio reaches the values of 0.7–1.5 and expresses the degree of accuracy of the automatically recorded data. In the case of affected data (adding up units, sensor covered) provided by the counter, an extrapolation of the data from the relevant periods is done, based on a combination of spatial correlation and time correlation of the data. During the calculation, hourly data of the period of at least 7 days before or after the

relevant interval (time correlation) for all the "neighbouring" counters (spatial correlation) were taken into consideration. Then the degree of correlation between the relevant counter and all the other counters was calculated; the counter with the highest level of correlation was chosen for next calculation. From this, the total visitor attendance is read in the time before and after the relevant period and this value is used to divide the total visitor monitoring by the relevant counter in the same period. Next, the daily and hourly values for the relevant counter in the relevant period are set. A Microsoft Office programme was used to evaluate the results.

Results and discussion

As stated above, the visitor monitoring was conducted and evaluated in two localities. An overview of the results of counting with the division into individual localities and months is presented below (see Table 1). The data presented in the Tab. 2 show that the most visitors in total (more than 26 tsd) as well as in the individual month were recorded in the monitored period by the counter in the locality of Na Flekačkách. The effect of holidays is quite significant in the locality of Na Flekačkách, i.e. there is high number of users mainly in July and August. The warm September weather had also a significant effect on the visitor attendance. In the locality of Amerika, the differences in the visitor attendance are not so significant. The most visitors during one month were recorded by the counter in the locality of Na Flekačkách in August. The lowest number of users, on the other hand, was counted in the locality of Amerika in October. Only decreases in the visitor attendance were recorded in the locality Na Flekačkách; thus, July is the month with most frequent visits to this locality. The highest absolute and relative decrease in the number of users was recorded in the locality of Na Flekačkách in October, as a result of colder weather.

Detail results from the locality of Amerika

An automatic counter was placed on the Amerika forest road leading from the ponds Trubka and Bašta towards the suburb of Budějovice and to Lení street. The surface of this 3.5 m wide forest road is made of dirt. The path is used by pedestrians and cyclists. In this locality, the counter was placed in a nesting box on a tree. Considering the width of the path, a partial underestimation of the number of users is probable since they can pass the counter in bigger numbers aligned behind each other.

Manual calibration counting was conducted during the 7 days of the week 11 – 17 July 2016. Based on the comparison of the data gained both manually and automatically, the calibration coefficient for the respective locality was set for the value of 1.14.

In the locality of Amerika, the highest number of users in total was recorded in August and September; the lowest, approximately by a quarter, was recorded in October.

A comparison of the number of path users in the locality of Amerika is shown in Tab. 3

In July, there were 3.948 passages recorded in the locality of Amerika. The daily average with all the days counted was 127 and the average hourly number was 5. The daily maximum of 184 was reached on Sunday, 3 July. The day of a week with the most frequent visits was Saturday. In August, 4,145 passages were recorded. The daily average with all days counted was 134 and the hourly number of records was 6. The daily average at weekends only slightly exceeded the overall daily average. The daily maximum of 201 was achieved on Sunday, 14 August. The day

of a week with the most frequent passages was Sunday. In September, 4,082 passages were recorded. The daily average with all the days counted was 136 and the hourly average number of records was 6. The daily average of the weekend days exceeded the overall daily average by almost 6%. The daily maximum of 210 was reached on Tuesday, 13 September. The day of week with the most frequent passages was Sunday.

Tab. 1: Comparison of the number of users of the selected forest roads of Lesy města Písku in the period between 1 July – 31 October 2016 (selected indicators, calibrated data)

Selected indicators of the number of path users	"Amerika"	"Na Flekačkách"
Total	15,312	29,100
Daily total	Sun 16 Oct 2016 (232)	Wed 28 Sep 16 (390)
Daily minimum	Wed 12 Oct 2016 (30)	Tue 4 Oct 2016 (48)
Day of the biggest frequency	Sunday	Sunday
Hourly average	5	10
Daily average	124	237
Monthly average	3,789	7,201

Tab. 2: Comparison of the number of users of the selected forest roads of Lesy města Písku in the period between 1 7 – 31 October 2016 (by months, calibrated data)

Month	"Amerika"			"Na Flekačkách"		
	Number of users	Absolute difference months	Relative difference months	Number of users	Absolute difference months	Relative difference months
July	3,948			8,615		
August	4,145	197	5%	8,369	-246	-3%
September	4,082	-63	-2%	7,342	-1,027	-12%
October	3,137	-945	-23%	4,774	-2,568	-35%

Tab. 3: Comparison of the number of path users in the locality of Amerika during the period between 1 July and 31 October 2016 (by months, calibrated data)

Month	"Amerika" in total		
	Number of users	Absolute difference in months	Relative difference in months
July	3,948		
August	4,145	197	5%
September	4,082	-63	-2%
October	3,137	-945	-23%

In October, 3,137 passages were recorded. The daily average of the records with all the days counted was 101 and the average hourly number of records was 4. The daily average for the weekend days (146) exceeded the overall daily average by almost 45%. The daily maximum of 232 was reached on Sunday, 16 October. The day of a week with the highest frequency of passages was Saturday. The plot (see

Fig. 2) shows a significant predominance in the number of pedestrians (90.8%) to cyclists (8.9%). Figure 3 shows the distribution of visitor attendance to the territory by days. It is clear from the chart that the day with biggest frequency of visitor attendance in the monitored period was Sunday (17.3%) followed by Saturday (15.7%). The other days of the week were more or less balanced and their ratios in the weekly attendance fluctuate from 12.6% to 13.7%.
Figure 4 depicts the distribution of the visitor attendance within the locality of Amerika by hours. With regard to the distribution of the number of users per hour during working days, the obtained data show two peaks: a relatively small morning peak between 8 and 11 a.m. and a very high peak in the afternoon between 3 and 6 p.m.

Detail results from the locality of Na Flekačkách

The automated counter was placed on the forest road between Na Flekačkách and the crossroads U Dobré vody. The surface of this 5.5 m wide forest road is made of bitumen; the road is used by pedestrians, cyclists and vehicles for forest works as well as by local inhabitants. The bike paths No. 1015 and Okolo Písku lead along this road. There is also an educative path "Forests". In that place, the counter was mounted in a nesting box on a tree. Considering the width of the path, it is anticipated that the number of users is partially underestimated since people can pass the counter next to each other in an alignment in bigger numbers.
In the locality of Na Flekačkách, the manual calibration counting was conducted during the 7 days between 11 and 17 July 2016. Based on the comparison of the data measured both manually and automatically, a calibration coefficient for the given locality was set with the value of 1.11.
The selected monitoring indicators are shown in Table 4.
A comparison of the number of path users is shown in Table 5. In the locality of Na Flekačkách, the highest number of users was recorded in July (8.6 tsd) while the smallest in October (4.7 tsd). The difference between the months with most visits and the least visits accounted for approx. 44%.

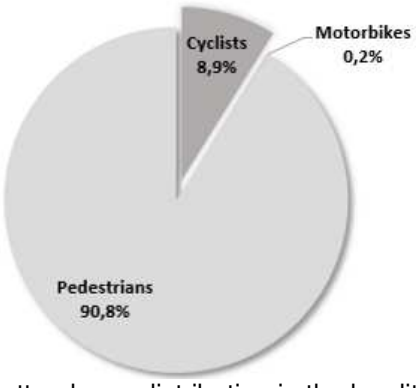

Fig. 2: A graph of visitor attendance distribution in the locality of Amerika during the calibration counting during 11 and 17 July 2016 (according to the type of user)

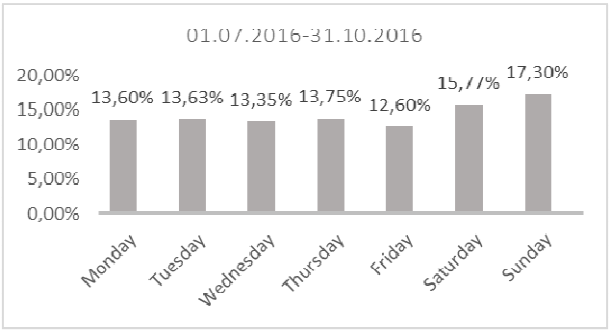

Fig. 3: A graph of visitor attendance distribution in the locality of Amerika in the period between 1 July and 31 October 2016 (by days, calibrated data)

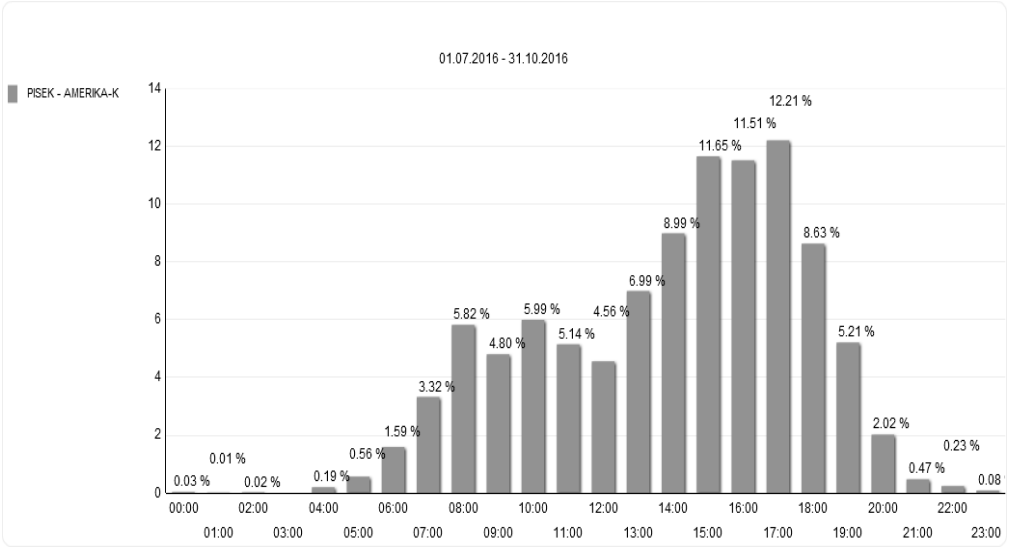

Fig. 4: A plot of visitor attendance distribution in the locality of Amerika in the period between 1 July and 31 October 2016 (by hours, calibrated data)

Tab. 4: Selected indicators of visitor monitoring in the locality of Na Flekačkách in the period between 1 July and 31 October 2016 (calibrated data)

Jul-Oct/2016	"Na Flekačkách" in total
Records in total	29,100
Daily total	Wed 28 Sep 16 (390)
Daily minimum	Tue 4 Oct 2016 (48)
Day of the biggest frequency	Sunday
Hourly average	10
Daily average	237
Daily average (working days)	224
Daily average (weekends)	267
Monthly average	7,201

Tab. 5: Comparison of the number of path users in the locality of Na Flekačkách during the period between 1 July and 31 October 2016 (by months, calibrated data)

Month	Na Flekačkách		
	Number of users	Absolute difference in months	Relative difference in months
July	8,615		
August	8,369	-246	-3%
September	7,342	-1,027	-12%
October	4,774	-2,568	-35%

In the locality of Na Flekačkách, the daily average with all the days counted was 278 and the hourly average of the number of records was 12. The averages from the weekend days and from the working days were similar. The daily maximum of 373 was achieved on Tuesday, 5 July, which was linked with that day being a bank holiday. The day of a week with the highest frequency of passages was Tuesday. In August, 8,369 passages were recorded. The daily average with all the days counted was 270 and the hourly average of the number of records was 11. The average from the weekend days was higher than the overall daily average by approx. 12% and the average of the working days by 1/5. The daily maximum of 369 was reached on Sunday, 14 August. The day of a week with the highest frequency of passages was Sunday. In September 7,342 passages were recorded. The daily average with all the days counted was 245 and the hourly average of the number of records was 10. The daily maximum of 390 was reached on Wednesday, 28 August, which is related to that day being a bank holiday. The day of week with the highest frequency of passages was Sunday. In October 4,774 passages were recorded. The daily average with all the days counted was 154 and the hourly average of the number of records was 6. The daily maximum of 269 was reached on Sunday, 16 October. The day of week with the highest frequency of passages was Saturday.

Figure 5 shows the distribution of visitor attendance in the locality according to the type of users. Based on the chart, it is possible to say that the number of pedestrians prevails (44.8%) above cyclists (27.7%) and cars (24.9%). A very small percentage of users are represented by motorbikers (1.2%), horse-riders (1.3%) and scooters (0.2%).

The distribution of the visitor attendance to the locality by days is shown in Fig. 6. It is clear from the plot that the day with most frequency in visitor attendance of the monitored period was Saturday (24.8%) followed by Sunday (22.4%). The days with the least frequency in the visitor attendance, on the other hand, were Tuesday (7.9%) and Wednesday (9.1%)

With regard to the hourly data gained during the working days, two peaks in distribution of number of users can be seen: a morning peak between 10 – 12 a.m. and a longer afternoon peak between 2 – 6 p.m. (see Figure 7).

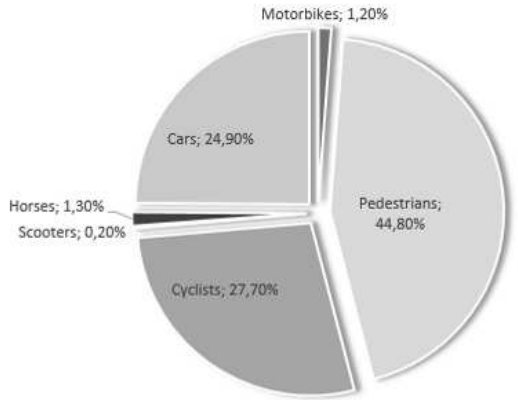

Fig. 5: A graph of visitor attendance distribution in the locality of Amerika during the calibration counting during 11 and 17 July 2016 (according to the type of users)

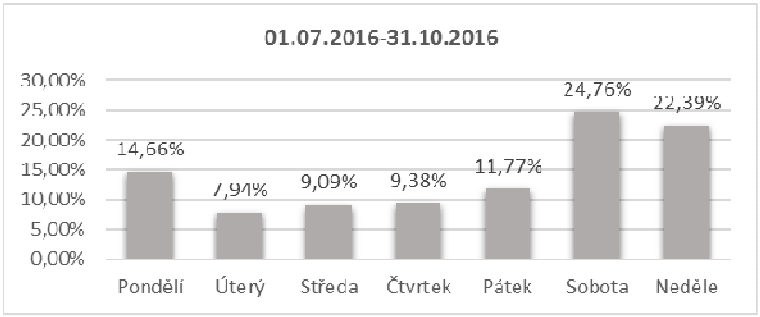

Fig. 6: A graph of visitor attendance distribution in the locality of Na Flekačkách in the period between 1 July and 31 October 2016 (by days, calibrated data)

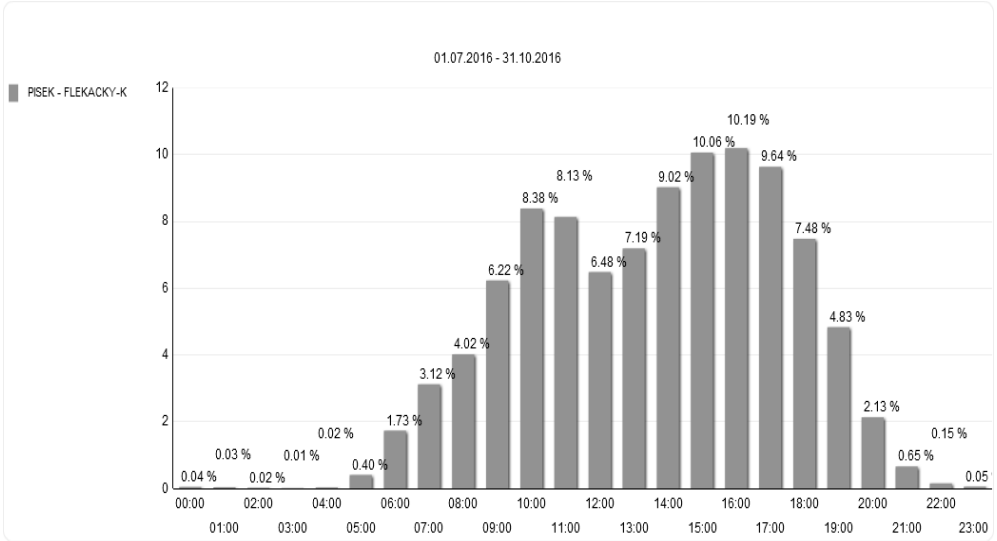

Fig. 7: A graph of visitor attendance distribution in the locality of Amerika in the period between 1 July and 31 October 2016 (by hours, calibrated data)

Conclusion

This paper presents the results of the research carried out in the territory of Lesy města Písku, Ltd. by the Department of Economics and Policy of Forestry and Wood Technology in cooperation with the Institute of Engineering Constructions and Landscape Planning and Protection of the Faculty of Forestry and Wood Technology of Mendel University in Brno in 2016. The article focuses on visitor monitoring in the forests of Lesy města Písku in the period between July and October 2016 by means of automated counting of visitors using field counting devices (pyroelectric sensors). The results show that the most users in one month (8,615) were recorded in July by the counting device in the locality of Na Flekačkách and, on the contrary, the least number of visitors (3,137) was recorded in October by the counting device in the locality of Amerika. The highest relative as well as absolute decrease in the total number of users by more than 2,568 (35%) in comparison with September was recorded in October. The months of summer holiday (July and August) were similar with regard to visitor attendance. In this locality, the influence of summer holidays is rather significant, i.e. there is a high number of users mainly in July and August. In the locality of Amerika, the day with the most frequent visitor attendance in the monitored period was Sunday (17.3%), while the day with the least frequent visits to the locality of Na Flekačkách was Saturday (24.8%). As for the hourly data during the working days, there are two peaks in the distribution of the number of users in both the localities, between 3 and 6 p.m. This article contributes to the research in the field of forest visitor monitoring and, above all, poses a basis for determination of the future interest and potential financial flows of Lesy města Písku resulting from the use of the interest area.

References

Barros, A., Gonnet, J. & Pickering, C. (2013): Impacts of informal trails on vegetation and soils in the highest protected area in the Southern Hemisphere. Journal of Environmental Management, 127: 50-60.

Blaha, P. (2010): Výsledky monitorování a jejich využití v praxi - Liberecký kraj. [The results of the monitoring and their practical application – Liberec Region]. Ochrana přírody, special issue.

Butler, R. W. (1980): The concept of a atourist area cycle of evolution: Implications for management of resources. Canadian Geographer-Geographe Canadien, 24(1): 5-12.

Daldeniz, B. & Hampton, M. P. (2013): Dive tourism and local communities: Active participation or subject to impacts? Case studies from malaysia. International Journal of Tourism Research, 15(5): 507-520.

Fialová, J., Kupec, P., Hlaváčková, P. & Šafarik, D. (2014): Visitor monitoring of selected trails in ŠLP Křtiny. In J. Fialova & D. Pernicova (Eds.), Public recreation and landscape protection - with man hand in hand? Křtiny, May 5-6, 2014: 340-343.

City Pisek Forests, Ltd. (2016): Profil společnosti. [Company Profile]. Available at: World Wide Web: http://www.lmpisek.cz/o-nasi-spolecnosti/profil-spolecnosti. (accessed on 30.9.2016)

Gökovali, U. & Bahar, O. (2006): Contribution of tourism to economic growth: A panel data approach. Anatolia, 17(2): 155-167.

Hall, C. M. & Frost, W. (2009): Introduction: The making of the national parks concept. In W. Frost & C. M. Hall (Eds.), Tourism and national parks: International perspectives on development, histories and change (pp. 3-15): London: Routledge.

Hardin, G. (1968): The tragedy of the commons. Science, 162(3859): 1243-1248.

Hlaváčková, P., Březina, D. & Meňházová, J. (2015): Selected results of survey focused on the economic assessment of forest ecosystem services. Journal of Forest Science, 61(7): 282-290.
Hlaváčková, P. & Březina, D. (2016): Economic evaluation of the recreational use of forests: A case study of the Training Forest Enterprise Masaryk Forest Křtiny. Journal of Forest Science, 62 (9): 389-398.
Ivanov, S. H. & Webster, C. (2013): Tourism's contribution to economic growth: A global analysis for the first decade of the millennium. Tourism Economics, 19(3): 477-508.
Kala, L. & Salov, T. (2010): Výsledky monitorování a jejich využití v praxi - České Švýcarsko. [The results of the moitoring and their use in practice – České Švýcarsko National Park]. Ochrana přírody, special issue.
Katircioglu, S. T. (2009): Revisiting the tourism-led-growth hypothesis for Turkey using the bounds test and Johansen approach for cointegration. Tourism Management, 30(1): 17-20.
Kos, J. (2010): Výsledky monitorování a jejich využití v praxi - Národní park Podyjí. [The results of the moitoring and their use in practice – Podyjí National Park]. Ochrana přírody, special issue.
Lew, A. A. (2011): Tourism's role in the global economy. Tourism Geographies, 13(1): 148-151.
Lück, M. (2008): The Encyclopaedia of Tourism and Recreation in Marine Environments. Wallingford, UK; CAB International, Cambridge, MA: 587.
Marzano, M. & Dandy, N. (2012): Recreationist behaviour in forests and the disturbance of wildlife. Biodiversity and Conservation, 21(11): 2967-2986.
Newsome, D. (2014): Appropriate policy development and research needs in response to adventure racing in protected areas. Biological Conservation, 171: 259-269.
Oian, H. (2013): Wilderness tourism and the moralities of commitment: Hunting and angling as modes of engaging with the natures and animals of rural landscapes in Norway. Journal of Rural Studies, 32: 177-185.
Sharpley, R. (2002): Tourism and development - A vehicle for evelopment? In R. Sharpley & D. J. Telfer (Eds.),Tourism and development. Concepts and issues (pp. 11-34). Clevedon: Channel View Publications.
Tang, C. F. & Abosedra, S. (2014): The impacts of tourism, energy consumption and political instability on economic growth in the MENA countries. Energy Policy, 68: 458-464.
Telfer, D., J. (2002): The evolution of tourism and development theory. In R. Sharpley & D. J. Telfer (eds.), Tourism and development. Concepts and issues. Clevedon: Channel View Publications: 35-80.
Thomas, F., Kapoor, A. & Marshall, P. (2013): Tourism development and behavioural changes: evidences from Ratanakiri province, Kingdom of Cambodia. Journal of Tourism and Cultural Change, 11(3): 208-219.
Weaver, D., B. (2001): The Encyclopedia of Ecotourism. CABI Publishing, New York: 668.
Williams, S. (2000): Tourism geography. London: Routledge.
Zahradník, D., Banaš, M. & Jirásková, E. (2012): Back and front of visitor monitoring - examples of good and less successful visitor monitoring in the Czech protected areas. Journal of Landscape Management, 3(1): 14-19.

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S**ouhrn**
Tento článek prezentuje výsledky výzkumu prováděného na území Lesů města Písku, Ltd. pracovníky Lesnické a dřevařské fakulty Mendelovy univerzity v Brně v roce 2016. Tento článek se zaměřuje na sledování návštěvnosti v lesích města Písku v období mezi červencem a říjnem 2016 prostřednictvím automatizovaného počítání návštěvníků využívajících pyroelektrické senzory. Tyto výsledky ukazují, že většina uživatelů v jednom měsíci (8,615) bylo zjištěno v červenci v lokalitě Na Flekačkách, a naopak nejmenší počet návštěvníků (3137) byl zaznamenán v říjnu v lokalitě Amerika. Nejvyšší relativní i absolutní pokles celkového počtu uživatelů o více než 2,568 (35%) ve srovnání se zářím byl zaznamenán v říjnu. Tyto měsíce letních prázdnin (červenec a srpen) byly podobné.

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VISITOR MONITORING IN THE PROTECTED AREAS OF THE CZECH REPUBLIC IN YEARS 2015 AND 2016

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Abstract
The contribution presents a comparative overview of the visitor monitoring results for the year 2015 from all large-scale Protected Landscape Areas of the Czech Republic. The number of visitors is measured by means of year-round automatic counting using monitoring sensors in a countryside environment. The text also presents the current results of visitor monitoring in 2016. Last but not least, the paper summarizes the current experience with this method of counting visitors in the protected landscape areas and discusses its use in the future, especially in the context of the alternative methods of collection of data on visitor numbers.

Key words: visitor, monitoring, management, protected area

Introduction

There is no doubt that visitor monitoring of natural attractions in Protected Landscape Areas can be described as a quickly developing research field. In the first half of the last decade, the data about number of visitors of the natural regions were collected by nature protection staff rather sporadically and the predominantly used method was manual counting. The number of visitors of selected localities was recorded by authorized staff on a few days of the years at most and the data on numbers of visits were subsequently converted into estimates of annual visitors numbers. Naturally, the quantity and the monitoring methods (and thus the amount of resources invested into this type of research) reflected the existing demand for such data at that time. The information about the number of visitors was actually utilized by researchers or individual protected area rangers who were taking care of extremely sensitive areas or areas endangered by visitors.

Nowadays, however, the situation in this field has changed significantly. The information about the number of visits in protected areas is used by two thirds of the protected areas in the category PLA (Protected Landscape Areas) and NP (National Parks). In the vast majority of cases, sophisticated methods of automatic data collection are used which enable to monitor the number of visitors 24 hours a day, 365 days a year. The monitoring is funded by NP and PLA administrations in charge through grants, but in most cases (especially in the case of PLA) from their own budgets.

One of the first protected areas where the visitor monitoring was carried out systematically and analysed were the NP České Švýcarsko (2005), PLA Beskydy (2009), and PLA Jeseníky (2009). In all three cases, the development of the visitor monitoring system was funded by EEA/Norway Grants.

The results of this research type which is financed by nature protection organizations are nowadays used abundantly also by local self-government, destination management, businessmen in tourism, etc. The information about the number of visitors of our Protected Landscape Areas, possibly also comparison with

the number of visitors in famous European or overseas natural destinations is also presented in media more and more.
In summary, the demand for the information about the number of visitors is so high that nature protection does not hesitate to invest considerable financial means into their gathering. Who would have said that fifteen years ago?

Methodical approaches to visitor monitoring in protected areas using outdoor counters and their analysis

The following data represent the comparison of the visitor monitoring results in 2015 in the natural areas where the visitor monitoring is conducted by PLA or NP administration. Those areas where visitor monitoring is conducted by institutions other than NP or PLA administration are not included in the comparison (e.g. counting devices operated by regional governments, non-profit organizations, etc.). Only the areas were included where the number of visits is monitored year-round using automatic outdoor counters and where other methods of data collection are only complementary. The results do not involve data from counting devices operated by NP Krkonoše administration. The local visitor monitoring using outdoor counters enables counting only part of the year due to rough climatic conditions (usually from April to November). In contrast to other mountain protected areas (e.g. Beskydy, Jeseníky, Jizerské hory), the visitor monitoring is not handled for the rest of the year, which excludes the area from the comparative analysis of annual visitor number.
Visitor traffic is monitored primarily by pyrosensors or infrared sensors which are installed on the key tourist infrastructure in the area. The sensors react to the passing of visitors on paths or roads. The basic unit of research is usually the number of people passing or riding in front of it. The method itself therefore does not take into account the situation when the path is used by the same visitor more than once. This can be factored in in the results only in those areas where it is evident that the monitored area is used repeatedly by most of the visitors (e.g. mountain tops with a single access path). According to the requirements of the individual protected areas, the counting devices in some localities are equipped with specialised sensors which enable to distinguish between individual group types (pedestrians, cyclists, cars) or between directional distributions of visitors on the path.
The basic automatic monitoring is usually complemented by regular manual counting which provides information about the accuracy of automatic counting. Potential breakdowns (climatic influence, vandalism, etc.) are counted in with the aid of mathematical and statistical methods. The recalculation is done with the use of the following data: the average number of visitors before and after the breakdown, the results from reference counting devices, the results of manual counting in the time of breakdown and their extrapolation for the period in question, etc.

The extent of visitor monitoring in protected areas in CR in 2015 and 2016

In 2015 (which is the main focus of this paper) the number of visitors was monitored in 118 natural areas (including devices in NP Krkonoše). 55 of the sites were located in National Parks (NP) and 63 in Protected Landscape Areas (PLA). The monitoring was conducted in 3 out of 4 National Parks and in 13 Protected Landscape Areas (out of total of 25 in 2015).
In 2016 the number of sites with visitor monitoring increased even more. Visitor monitoring was conducted at 154 sites. It was newly introduced in NPA Brdy, Blanský les, Broumovsko, Labské Pískovce, Pálava and Železné hory. While the

number of monitored sites in National Parks remained the same, the number of sites in PLAs rose to 99 in 18 PLAs (out of total of 26 in 2016).

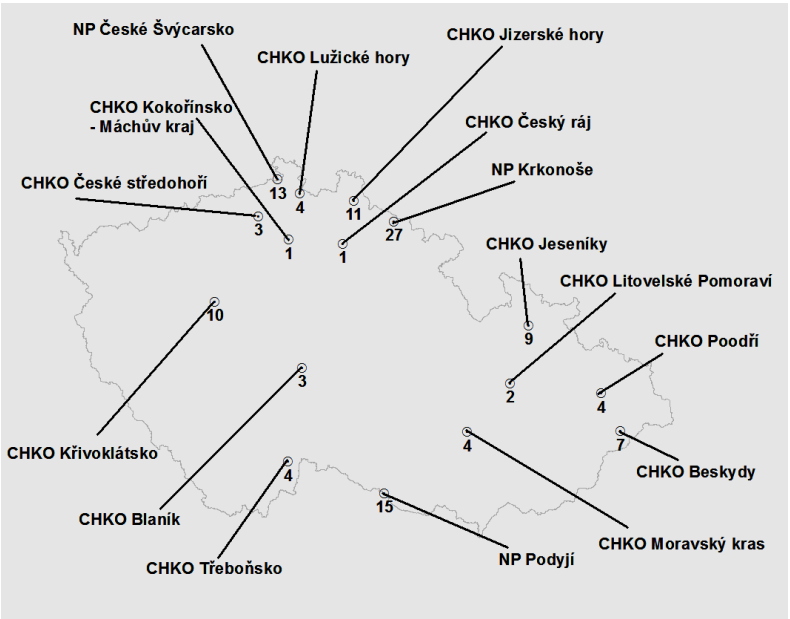

Fig. 1: The number of sites with automatic visitor monitoring in National Parks and Protected Landscape Areas of the Czech Republic in 2015

The results of visitor monitoring in protected areas in 2015

The most frequented monitored tourist route in a protected area in 2015 was the ridge path leading from Pustevny to Radegast statue in PLA Beskydy. It is an undemanding route east of the National Nature Reserve Radhošť and in 2015 around a quarter million visitors were counted there (see Fig. 2). Slightly lower figure was recorded on the main access route to the highest peak of Moravskoslezské Beskydy mountains, Lysá hora (PLA Beskydy). It must be mentioned that the local visitor traffic is influenced by a number of organized events for public which have a tradition on Lysá hora (group mountain climbs, mountain marathons, etc.). The third most frequented monitored path was a route through Edmund's gorge (Edmundova soutěska) in NP České Švýcarsko. The recorded number of passing visitors was more than 180 000.

Apart from the official tourist infrastructure, 11 unofficial unmarked paths were monitored in 2015 as well. The most frequented path was a forest path along the Kačírek pond in National Nature Reserve (NNR) Polanská niva (PLA Poodří). Despite the fact that this path is off limits because of its level of protection and the visitors caught there could be penalized, the total of 42 941 passing pedestrians and cyclists was counted there. Another unofficial path was monitored in PLA Beskydy. It was the access path to the peak Kněhyně in NNR Kněhyně - Čertův Mlýn. Despite the mechanical barrier at the beginning of the path, 4 205 visitors trespassed. Off limits paths in PLA Křivoklátsko are monitored in NNR Vůznice and NNR Týřov. In 2015, 11 461 trespassing visitors were counted on 6 paths.

Rank	Site	Protected Area	Counted number of passing visitors
1.	Pustevny - Radegast	PLA Beskydy	250 761
2.	Lysá hora - from Ostravice	PLA Beskydy	232 182
3.	Edmundova Soutěska	NP České Švýcarsko	183 732
4.	Tři prameny	NP České Švýcarsko	155 352
5.	Lysá hora – northern access	PLA Beskydy	140 027
6.	Gabrielina stezka	NP České Švýcarsko	140 043
7.	Praděd	PLA Jeseníky	131 675
8.	Bílá Opava Valley	PLA Jeseníky	99 637
9.	Knejpa - Pod Jizerou	PLA Jizerské hory	96 443
10.	Mezní můstek - Mezná	NP České Švýcarsko	93 207

Fig. 2: Ten most visited touristic paths in protected areas in 2015.

Visitor monitoring of off limits paths which run through areas where visitor traffic is problematic serves as efficient feedback for nature protection staff. The results of monitoring suggest how successful they are in terms of communication with public, or how they succeed in defending the protected areas against public.

The following overview (see Fig. 3) presents the average visitor number in individual protected areas for one counting site (only official tourist infrastructure). It is necessary to realize that in each area a different number of sites is monitored and it is not always the aim to choose the most frequented paths in the area. The most frequented paths chosen for monitoring were located in PLA Beskydy. Two main access routes to Lysá hora, the ridge paths on Velký Polom, Smrk and Radhošť and the educational trail in NNR Salajka were monitored there. A monitoring device in PLA Český ráj monitored a path through Plakánek valley and the counted number was 88 thousand passing pedestrians a year. The third most frequented site were paths monitored in PLA České Švýcarsko. The lowest average visitor traffic was found on the paths in PLA Blaník. However, it must be mentioned that all three local counters were located on the paths running through ecologically sensitive sites where there could arise a conflict between visitor traffic and the subject of protection (Nature Reserve Malý Blaník, National Nature Monument Medník a National Nature Monument Drbákov - Albertovy skály). They were not primarily chosen in order to record a high number of visitors. Sites such as Velký Blaník or Kaňk by Kutná hora, which are the most interesting tourist sites, were monitored in the area PLA Blaník until 2016.

If we compare the average number of visitors on official tourist trails monitored in Protected Landscape Areas with the trails monitored in National Parks, a surprising fact becomes clear. Whereas the average number of visitors of the trails monitored in PLAs was 45 409, the trails in NP had 43 063 visitors on average. Consequently, the monitored sites in PLA had a higher average number of visitors than sites monitored in NP which are generally more visited. It can be assumed that the result would change significantly if visitor monitoring data from paths popular by tourists in NP Krkonoše or Šumava were included in the comparison. Visitor monitoring in those protected areas is not conducted yet.

Protected area	The average number of passing visitors at one site
PLA Beskydy	111 714
PLA Český ráj	88 552
NP České Švýcarsko	64 733
PLA Kokořínsko - Máchův kraj	52 354
PLA Jeseníky	53 516
PLA České středohoří	39 638
PLA Jizerské hory	35 308
PLA Třeboňsko	34 454
PLA Litovelské Pomoraví	31 378
PLA Lužické hory	27 830
PLA Poodří	26 727
NP Podyjí	23 320
PLA Křivoklátsko	16 942
PLA Blaník	5 661
Total average	**43 723**

Fig. 3: Protected areas according to the average visitor number on one official tourist route in 2015

Finally, the last piece of information about the number of visitors of protected areas in 2015 concerns the time when most visitors arrived. Aggregate date from all available counters show that most tourists were on Protected Landscape Areas and National Parks paths in August (636 328 counted visitors) and July (602 175 people). On the other hand, the paths were most deserted in January (123 014 people) and November (127 175 people). In 2015 the total number of passing visitors on the 118 monitored corridors was 3 460 540.

Visitor monitoring in 2016

While this text is being written (April 2017), the data from all sites monitored in 2016 are not available yet. However, some current partial results are already available and it is possible to publish them. An interesting and evidential correlation of visitor number in relation to the locality in question was recorded in NNM Medník (PLA Blaník).

While the visitor traffic at most of the monitored sites is found to be the highest in the summer, when the conditions for hiking are the best, the visitor traffic at Medník site was highly disproportional, favouring March and April when almost 50% of the annual visitor number was recorded (see Fig. 4).

The subject of protection in this woody area is an endemic monocotyledonous plant *Erythronium dens-canis*. In the Czech Republic the plant is found only in the Medník area. The considerable seasonal peak of visitor traffic in this area corresponds closely to the blooming season of this unique plant species which begins in mid-March and ends in mid-April.

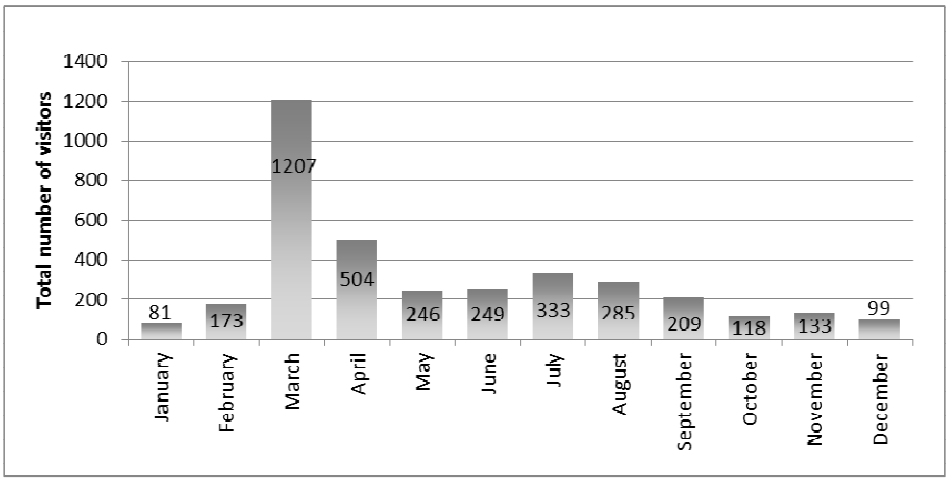

Fig. 4: Distribution of the visitor traffic in NNM Medník (PLA Blaník) in 2016

The future of visitor monitoring in protected areas

Nowadays, outdoor counter systems can be seen as a well-established tool for visitor monitoring, not only in the Czech Republic but also in other countries in Western Europe or North America. Recently, another method of visitor monitoring has become more widely known. It is visitor monitoring using residual positioning data from mobile networks. In a simplified way, the method is based on the principle that users' SIM cards are detected according to users' position by diverse transmitters and the mobile operator disposes of more or less accurate information about the number of clients who are at the given time in the space cell delimited by the range of the transmitter.

Compared to monitoring in the field with the help of sensors, the use of this method for the purpose of nature protection can be seen as arguable so far. Whereas the counters capture the real situation at the site (with higher or lower deviation), the residual data method represents in principle a qualified estimate of visitor number. It is because the operator in the target area registers only "his" users (SIM cards) and the remaining visitor number is counted up according to the operator market share. The aim of this kind of monitoring may appear questionable as well. From the perspective of protected areas management, the desirable data include information about visitor traffic on specific paths and their sections. The method of residual data does not usually manage to provide such subtle differentiation. Moreover, the financial aspect of residual data method compared to counting sensors does not appear so attractive. Despite all these facts, the residual data method represents an incredibly interesting segment in the field of visitor traffic research and it will certainly be interesting to follow what possibilities its development will bring in the future.

A pilot project of Nature Conservation Agency of the Czech Republic focused on visitor monitoring of selected areas ends in 2017. It has been carried out in those Protected Landscape Areas whose management was interested in this type of research. In the second half of spring 2017, a seminar focused on the evaluation of the benefits of the current model of visitor monitoring data collection will take place at the Agency headquarters and its continuation will most likely be discussed. It might be expected that the number of visitors of protected areas of the Czech Republic will continue to be counted with the aid of outdoor counters. Another thing

which pleads in favour of this method is the existence of historical data which can serve as a point of departure for future visitor monitoring.

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Souhrn
Text představuje výsledky monitoringu návštěvnosti za rok 2015 ze všech velkoplošných chráněných území České republiky, kde je návštěvnost měřena metodou celoročního automatického sčítání návštěvníků prostřednictvím terénních sčítacích senzorů. Rovněž jsou uvedeny vybrané zcela aktuální výsledky monitoringu z roku 2016. V neposlední řadě text shrnuje stávající zkušenosti s touto metodou sčítání návštěvníků chráněných území a zamýšlí se nad jejím uplatněním v budoucnu, a to zejména v kontextu alternativních metod sběru dat o návštěvnosti

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WASTEWATER TREATMENT SPECIFICS IN PROTECTED LANDSCAPE AREAS

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Abstract
Requirements for the water management in environmentally sensitive areas are antithetical. On the one hand, we need a user-friendly system burdening the environment as little as possible, while on the other hand, this can be challenging in terms of technology. Discussion topics and solutions are offered in this article.

Key words: unsteady flow, nitrogen, extreme requirements

Introduction

This contribution is focused to the problems of wastewater handling and disposal in buildings and similar structures situated in protected landscape areas (PLAs). Basically, this often concerns solving of a “isle house” problem with significantly irregular activities in exposed localities of increased environmental protection. Very often, it concerns solutions for extremely formulated requirements for wastewater treatment. Although it does not seem likely, even here several options can be considered for this task solution reflecting concrete conditions in the given locality as well as comfort and cost considerations in terms of capital and operating expenditures. This contribution deals with a comparison of several options: ”high-tech“, natural solutions and the so-called NASS system using the separation of water streams already within the sanitization step (Fig.1). After all, the simplest solution for conditions with the possibility of direct penetrations into e.g. cavern water streams is paradoxically the dry/pail toilet options. Nevertheless, this solution brings or may bring about some difficulties as regards the current legislation of the Czech Republic.

NASS systems

Apart from the usually offered decentralised systems that are not well-known in the general public, also the methods of the NASS systems (New Alternative Sanitation Systems) can be used for the reduction of the wastewater production. This acronym has been chosen because of an unconventional approach to the sanitization process, and also due to the fact that these systems should be “organised” according to the local conditions, similarly to, for instance, kitchens, bathrooms, or living rooms.

By the use of the NASS systems, various objectives may be pursued such as water consumption savings, waste disposal and processing, as well as a possibility of an adjustment of wastewater solutions to local conditions. For instance, various concepts make possible the utilisation of sources occurring in wastewater. The sludge can be locally used locally as a fertiliser for agricultural purposes, while greywater for irrigation or as non-drinking water in households. Problematic trace elements can be efficiently intercepted and due to the contamination-concentrated stream (see the German DWA-A 272 Working Paper) correspondingly eliminated.

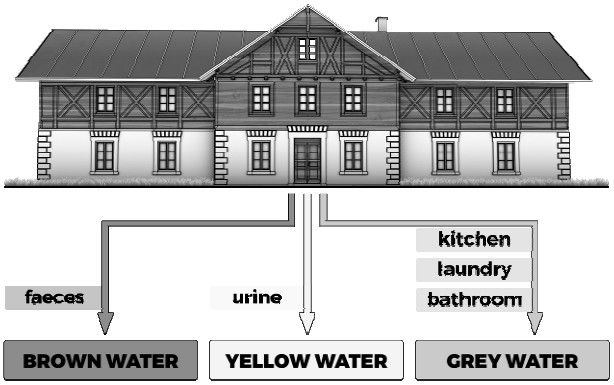

Fig. 1: Allocations of municipal wastewater (Asio)

In original assumptions, the NASS potential was considered as a solution for hardly accessible and demanding rural areas with unfavourable spatial distribution and high-standard environmental requirements. In spite of obvious advantages of the NASS systems, they still do not belong among standardised methods of wastewater disposal. So far, the expertise for their design and utilisation is not widespread enough to become a standard, but owing to some research and pilot projects, there are already design-supporting documents (PPN) in place. For instance, under the conditions in the Czech Republic, they are represented by “ASIO PPN NASS”. On the other hand, their disadvantage consists in the fact that they are not of a universal character. A characteristic feature of the NASS systems consist in the individuality of potential solutions, which means that each of them must be solved (arranged) on an individual basis. It is necessary to accept the fact that there is no easy-going statement as to what can be the best solution method.

Isle houses in general

Perhaps the most reasonable procedure would be to start with a balance of potential inputs, outputs and inner recycles. Among assumed water sources might be considered a public water main (if available), a well, water streams, or rainwater. The output include also rainwater and used water; their disposal can be solved by evaporation (evapotranspiration), infiltration or discharging into a water stream. From the analysis of sources and the inventory of discharging possibilities, a wide range of combinations may result and they will differ in their demand for capital and operating expenditures. In the search for the most suitable option, both objective (calculable) arguments as well as subjective assumptions are decisive, but also including ignorance or laziness to look for optimum solutions. As for the latter, the future user is then more or less rightly punished.

Applications of isle house issues to karst areas

Sometimes, collective tourism and environmental protection make strange bedfellows. It stands to reason that many people wish to see an interesting natural monument, which means that in such localities there is an interest to build supporting facilities, both for commercial and practical (hygienic) reasons – i.e. the public toilets. So the designers are confronted with the task of wastewater

management of the “isle house” type at an exposed place with the high standards of environmental protection.

General

A decision on the selection of a suitable solution will be based on several parameters at the same time:

- Water source (in karst areas, there is not usually a problem to find a water source on the spot)
- Power supply (there is usually no problem to bring power supply to the place)
- Access to the locality for sludge removal trucks plus the transport distance for the sludge removal
- Possibility of discharging to underground and surface water under the existing legislation requirements
- Number of visitors, seasonality.

Accessibility of the relevant locality and wastewater disposal

(a) Direct discharging and pumping of wastewater to public sewer systems – of course, this is the smartest solution.

(b) Transport of wastewater from localities that cannot be connected to a wastewater treatment plant. This is the least controversial solution, but in its character also the most expensive and sometimes not environmentally friendly

(c) Solutions in the place of wastewater occurrence are demanding in the case of irregularly used facilities.

An example of the solution for an information centre building in a protected landscape area

Most clearly, the above issues can be demonstrated on several examples. More important than obvious, it will be the interpretation of requirements for the visitor comfort and financial possibilities. Secondly, it will be important to reflect the possibilities existing in a concrete locality with regard to the locality itself as well as the legislation that may – ironically – frustrate the best possible solution.

At present, there is designed a building of an information centre in a protected landscape area (PLA), which is to be visited irregularly. In some days, even the number of 1,000 of visitor per day is expected, while the access there is restricted for another part of the year. The PLA Administration requires the highest user comfort for the building facilities, however the conditions in terms of wastewater discharging are limited, and the legislation in place is strict. We have proposed and several options.

Option (a): Comfortable flush toilets without any water stream separation and a high-tech process for cleaning with substrate dosing, phosphorus precipitation and membrane bioreactors (MBRs) – a solution usually used in luxury mountain chalets in the Alps.

Option (b): Flush toilets with urine separation in women segment plus waterless urinals; the wastewater solution based on a septic tank (anaerobic reactor), a vertical filter, and urine receivers.

Option (c): Dry toilets for tourists, flush toilets for the staff – cesspools for excreta from dry toilets; the wastewater solution based on a septic tank for the staff, a vertical filter, and urine receivers.

Option (d): Comfortable flush toilets with the solution: septic tank + vertical filter + sorption filter. (Note: Option (d) has been excluded for legislation reasons, unrealistic demand for the area and problematic removal of N_{total} under the level of 20 mg/l).
Option (e): see Australia – container flush toilets with minimisation of water consumption. Flush toilets for the staff solved through a septic tank plus a vertical filter.

Results
Based on the above-specified options, the selection of a suitable solution was made.

An assessment example

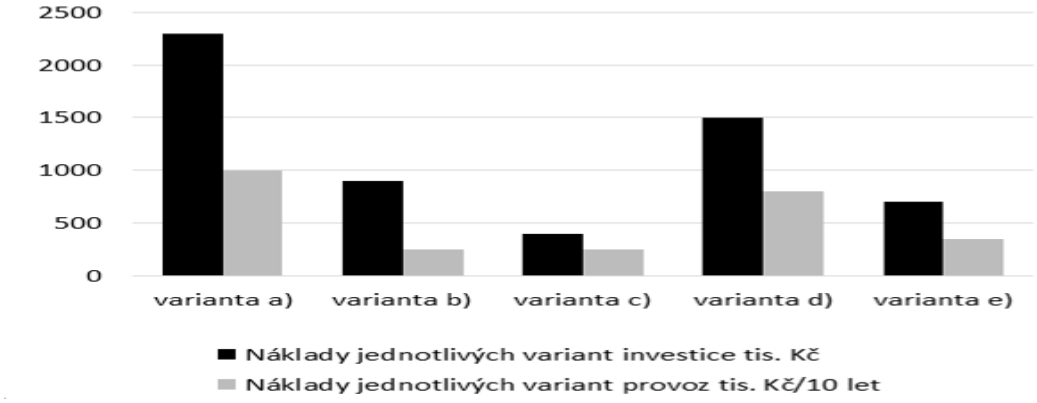

Fig. 2: An assessment of individual options (Asio)

Option (a) Option (b) Option (c) Option (D) Option (E)
Costs of individual options – capital expenditures in CZK '000
Costs of individual options – operating expenditures in CZK '000

In the end, only two options, (b) and (c), remained in the considerations as cost acceptable and reflecting the comfort requirements. However, it is necessary to note that we still have a distorted attitude to dry toilets that passed through a significant progress in their development, particularly due to Bill & Melinda Gates Foundation.

Discussion
It is obvious from various offers and results that the discussion over potential solutions may be concluded with a proverbial statement - as you have made your bed so you must lie in it. Actually, a discussion on the Alpine Association Conference ended exactly in this manner. The differences in requirements for comfort are often so great that a universal solution is sought only with difficulties.
During my visits to Australia and New Zealand, I paid a special attention to the problems in such localities and, at the same time, I observed reactions of people there. It seemed that dry toilets there were non-conflicting. In addition, there is a new possibility: the dry (composting) toilets can be constructed in a luxury design.


Fig. 3: Examples of dry toilets in New Zealand (Asio)

Conclusions

The discussion result may bring an observation that such facilities can be divided to luxury and touristic ones, and due to this, they will be designed at various price levels. We can only note that dry toilets represent in principle a versatile solution and instead of making a decision about suitable treatment technology; we will only decide what kind of toilets should be used – either simple or high tech facilities.

Dry toilets and waterless urinals

Whether we like it or not, dry toilets represent - in the end - the most environmental-friendly solution and it is only the matter of time, when they become the most economical solution as well. There are two aspects – a pushing aspect, where the current legislation is developing to the situation where each excrement has to be registered and carried to a central treatment plant (being the most "environmental-friendly" equipment?) or a pulling aspect representing new waterless solutions strongly supported by people with visions (such as the above-mentioned Bill & Melinda Gates Foundation).

In addition, waterless urinals and composting toilets may represent the best solution in terms of wastewater discharging – no water is simply produced.



Fig. 4: Examples of dry fixtures and fittings: urinals and composting toilets (Asio)

Overall conclusions

It is rather obvious that each locality will be solved individually in the end, always with regard to local conditions and requirements in terms of the user comfort. A

significant role will be played by the price of such solutions plus operating costs. However, even today it is evident already that the best solution in the future will not handle any wastewater, because no wastewater will be produced and sanitary facilities will be incorporated within waste management systems (but of course, this remains to be arranged as well). The whole circle will be closed along a spiral – from simple dry toilets we will pass through a sorrowful path edged with epidemics again back to the waterless solution. In doing this, an intermediate stage in the form of the NASS may be sometimes necessary for the cost reasons.
Solution – it is just simple – instead of high-tech treatment plants, high-tech dry toilets.

References

Asio:In-house documents of ASIO, spol. s r.o.
EPA Guidelines (2003): Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems, EPA.
ZIFU Li CSES (2016): Urban sanitation technology development. Reinvent the Toilet Challenge in China 13th IWA Conference 2016 in Athens

Souhrn

Požadavky na hospodaření s vodami v citlivých oblastech jsou protichůdné - co největší komfort (standardně chtěné jsou splachovací záchody), což dnes představuje větší spotřebu vody a proti tomu co nejmenší zatížení prostředí nutrienty, zejména fosforem a dusíkem z odpadních vod. Příspěvek nabízí jak high tech řešení, s využitím mebrán a řízeným dávkováním substrátu, tak i extenzivní řešení s využitím vegetačních čistíren nebo tzv. NASS přístup, který je založen na dělení vod (zejména oddělení moči) a diskuzi nad nimi. Uvedeny jsou příklady z praxe a jejich řešení. V závěru jsou pak do úvah začleněny i suché záchody (nebo kompostovací záchody), které díky novým technickým řešením, jsou možnou perspektivní alternativou v budoucnu. Jak moč, tak exkrementy obsahují hlavní podíl nutrientů, a tak nakonec vychází náklad na high tech toaletu a starost o ni efektivněji, než high tech čistírna odpadních vod. Nejlepší řešení je tak nakonec jak to bývá nejjednodušší – když nebudeme nic vypouštět, tak to nic nemá jak ovlivňovat životní prostředí. Jen je potřebné to všechno dořešit až do konce, jak jsem viděl na jednom záchodě – proces končí papírem.

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WATER ELEMENTS OF CULTURAL HERITAGE AND HISTORICAL SITES IN THE RELATIONSHIP TO THE LANDSCAPE STATE AND CLIMATE CHANGES

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Abstract

Water elements represent a significant part of the environment of cultural heritage sites, conservation zones and areas. To fulfil the required functions, which may include social, historical, recreational and educational, but also environmental functions; it is necessary to ensure their corresponding target state. This state includes structural-technical state and qualitative state. The article presents a methodical approach for describing both of the states and an evaluation of a threat of the negative changes. It also presents results of the Czech UNESCO Heritage sites water elements field survey of the structural-technical state, water management, connection to a surrounding landscape type (including land-use, pollution sources) and measurement of the quality of the aquatic environment.

Key words: cultural heritage, water management, water quality, pond, garden, tourism

Introduction

Historical parks and gardens from the Renaissance until 1960 include various types of gardens and artistic conception of space within them. They consist of structural elements (including water elements – e.g. small natural water areas, artificial channels, fountains, etc.) and vegetation elements and are part of the landscape, artificially and artistically designed or modified by man (Pacáková-Hošťálková et al., 2004; ONLINE 1). The view of the historic gardens changed considerably in the 20th century. Until nature conservation became a socially established practice in the 1970s, the determination of the heritage quality of historic gardens and parks was mostly based on their artistic merit. The idea of nature conservation has brought a shift in the view of parks and gardens: natural sceneries with their habitats for fauna and flora started to be regarded as highly as artistic qualities. With the establishment of the protection of historic gardens their value has also changed: the main role in the assessment of gardens and parks was played by their (cultural-) historical significance. Today, historic gardens and parks are perceived in their complexity. In many cases, disputes between nature conservation and the preservation of historical character of a garden changed to an approach allowing both views to be reconciled (ONLINE 1). Approaches to the revitalization and restoration of historic gardens after the period of totalitarianism are presented on the example of Poland by Wener (2011).

Historic parks and gardens represent extremely valuable, inimitable and irreplaceable cultural heritage of the past (Kříž et al., 1978). They can also form significant areas in terms of nature and landscape protection, including, water-dependent habitats, e.g. the Lednice-Valtice Cultural Landscape, or the ponds

system in the Třeboň region (Rožmberk National Cultural Heritage), Kroměříž gardens, as stated e.g. by Chytil, Hakrová (2001).
In terms of hazards posed to water elements, we may identify in particular the threat to the quality of their water environment (flow of pollution from point, area and diffuse sources of pollution), endangering of the spatial characteristics (the process of gradually filling in with detritus and turning into land, clogging, drying up, etc.) and the threat to the quality of the accompanying vegetation (spreading of invasive species, threat of drought, flooding, changes in groundwater levels, pests and diseases, etc.). Contamination of sites from leaking sewerage and sumps, especially during floods, is described as one of the problems by Krčmář (2003). A significant role in compromising the quality of landscape water elements is played by water eutrophication (Rozkošný et al., 2011; Všetičková et al., 2012). A major problem is also the deposition of sediments and gradual siltation and subsequent overgrowing with vegetation, which can pose a problem also in case of water elements of heritage sites that are connected to surface water bringing erosion downwash (Kvítek, Tippl, 2003). Changes in chemistry and groundwater level could affect water supply of ornamental lakes, fountains and other water elements (Holman et al, 2001; Hulme et al, 2002).
The impact of climate change on parks and gardens was documented in the work of Bisgrove and Hadley (2002). Findings of this research confirm that many of the factors that affect buildings and archaeology sites also have an impact on historic parks and gardens. Many historic parts of the landscape were damaged or destroyed as a result of mainly local events associated with extreme weather conditions; in addition, there are concerns now that the climate change may make it difficult to restore the original state.
Maintenance and monitoring of the state of heritage sites, including parks and gardens and water elements, will according to Cassar, Pender (2005) play a significant role in connection with climate change and the occurrence of extreme weather conditions.

Materials and methods
We used our own methodical approach for the description of the structural and qualitative states and an evaluation of a threat of the negative changes. The methodology for assessment of the threat to the state of water elements, the quality of their environment and the state and diversity of water-dependent habitats that are part of UNESCO heritage sites, cultural heritage sites, conservation areas and zones is divided into three parts.
These parts are as follows:

Part I	assessment of the state of water elements
Part II	assessment of the quality of the aquatic environment
Part III	assessment of the threat to the state of aquatic habitats

The first and third parts are based on a questionnaire, while the second part is based on the analysis of water samples (concentration of nitrogen, phosphorus, water trophic potential) and the classification of water eutrophication.
The basic principle of the methodology is that individual water elements located within a historical site are evaluated separately. For these elements, an assessment of all three parts is undertaken. After classifying the degree of hazard in individual parts, the worst rating from these three parts is selected as the relevant indicator. This rating is valid for the given water element.

A similar methodology was published by Lidblom (2012. The issue of addressing and assessment of hazard to heritage assets in the process of assessment of the environmental impacts is dealt with on the basis of a similar approach. The approach is based on a detailed questionnaire survey, which takes into account the historical, social, cultural and environmental aspects, and on its statistical processing.

Results

The following levels of hazard to the state and quality of water elements and water-dependent habitats have been defined:

0 - None

The site assessed does not include any water elements or habitats.

1 - Low

Low level of hazard to the state of the site. *The state corresponds to the conditions of the given site, being stabilized, without the need for interventions to stabilize or improve the current state.*

2 - Medium

Medium level of hazard to the state of the site. *There are critical phenomena leading to a threat with a potential of early disruption of the state, function, quality of the aquatic environment, habitat composition, excessive spread of invasive species, deterioration of aesthetic function.*

More extensive interventions need to be planned, to be implemented as part of the annual maintenance, or when funds (grant programs) to improve the situation are obtained.

3 - High

Critical condition, risk of permanent damage, deterioration and degradation.

Interventions should be planned as soon as possible, no later than within two years. Interventions to be implemented as part of annual maintenance need to be planned, leading to immediate resolution of the critical situation. Furthermore, strategic measures of a more extensive nature changing the general adverse conditions need to be planned.

The Table 1 shows evaluation of the threat, the worst values identified for the all single water elements of the mentioned UNESCO site in the three parts of the methodology. There are no water elements in the sites: Olomouc (the UNESCO Heritage site is a sculpture in the city center), Zelená Hora pilgrimage church and Sedlec (part of Kutná Hora town) cathedral. The worse level of hazard from the eutrophication point of view was calculated in many natural-like water elements (ponds, ornamental ponds, canals, or sections of watercourses). From the structural and operational evaluation view, the most of water elements of the sites (mentioned in Table 1) were in good condition, functional. Many of them were reconstructed in recent years.

Conclusion

The results of the methodology testing showed that in case of the aquatic environment quality is potential threat deterioration relatively high in the most shown sites, and relates to the water eutrophication with an impact on the aesthetic perception of the elements (colour of water, smell, overgrowth of algae and invasive plants, etc.). This is determined either by the supply of surface waters (main source of nutrients), or even by atmospheric depositions.

Tab. 1: Evaluation of the threat of water elements at UNESCO sites

Locality	UNESCO area	Technical and operational status of elements	The quality of the aquatic environment	Habitat quality
Brno	Villa Tugendhat	1	1	0
Český Krumlov	Castle garden	1	1	2
Holašovice	Village center	1	2	2
Kutná Hora	Sedlec cathedral	0	0	0
	Town center	2	2	0
Kroměříž	„Květná“ garden	1	1	1
	„Podzámecká“ garden	3	2	3
Lednicko-valtický areál	Lednice castle garden	1	3	2
	Valtice castle garden	1	1	0
	other localities	2	3	3
Litomyšl	Castle garden	2	2	1
Olomouc	City center	0	0	0
Praha	Břevnov monastery	1	1	0
	Průhonice castle garden	1	3	3
	City center parks	1	2	1
Telč	Town center	2	2	1
Třebíč	Jewish quarter	1	2	0
Zelená Hora	Pilgrimage church	0	0	0

Against sensory substantial quality deterioration of the aquatic environment it is often necessary to apply various chemical or biological agents, which keep the environment in a satisfactory condition (e.g. chlorination). It is also important regular cleaning. Despite many of gardens and parks have been restored in recent decade, including water elements, in some cases there were recorded also bad structural state of the elements. For example, in case of ponds and small artificial basins, wrongly functional outlet or inlet structures, bank erosion, etc.

As far as the given complex, cultural heritage site, conservation area or zone is concerned, it is the degree of hazard posed to a particular water element that has been identified as the worst that applies. Since the resulting value of the degree of hazard corresponds to the worst degree ascertained, when methodology application is evaluated, or when determining the parameters and influences that caused the state identified, it is recommended that a detailed analysis of the assessment as such and finding of the key elements and impacts affecting the severity of the rating, or, in other words, the degree of hazard ascertained, be performed.

References

Bisgrove, R. and Hadley, P.(2002): Gardening in the global greenhouse: the impacts of climate change on gardens in the UK, Technical Report, UKCIP, Oxford. 2002.

Cassar, M., Pender, R. (2005): The impact of climate change on cultural heritage: evidence and response. 2005. http://eprints.ucl.ac.uk/5059/1/5059.pdf (cit. 31. 01. 2012).

Holman, I. et al. (2001): The REGIS Project (CC0337) Regional climate change impact and response studies in East Anglia and in North West England. 2001. <http://www.silsoe.cranfield.ac.uk/iwe/projects/regis/> (cit. 31. 10. 2012).
Hulme, M. et al.: Climate change scenarios for the United Kingdom: the UKCIP02 Scientific Report, Norwich, UK. 2002.
Chytil, J., Hakrová, P. (eds.) (2001): Wetlands of the Czech Republic – the list of wetland sites of the Czech republic. – Czech ramsar Committee, Mikulov. Třeboň: JAVA publish. 2001.
Krčmář, I. (2003): O povodních z časového nadhledu. [Vlhkost budov po povodních a zvýšená vlhkost obecně - jak proti ní bojovat.]. Zpravodaj STOP. Časopis Společnosti pro technologie ochrany památek, 5, 2003, č. 1, s. 18-28.
Kříž, Z., Riedl, D., Sedlák, J. (1978): Významné parky Jihomoravského kraje. Brno.
Kvítek, T., Tippl, M. (2003): Ochrana povrchových vod před dusičnany z vodní eroze a hlavní zásady protierozní ochrany v krajině. Praha: ÚZPI. Zemědělské informace. (NS), č. 10/2003.
Lindblom, I. (2012): Quality of Cultural Heritage in EIA; twenty years of experience in Norway. Environmental impact Assessment Review 34 (2012): 51-57.
ONLINE 1: Cultural (garden) heritage as a focal point for sustainable tourism. http://www.culttour.eu/en/homepage/ (cit. 30.10.2013)
Pacáková-Hošťálková, B., Petrů, J. Riedl, D., Svoboda, A. M. (2004): Zahrady a parky v Čechách, na Moravě a ve Slezsku. Praha: Nakladatelství Libri. 2004, 526 s.
Rozkošný, M., Adámek, Z., Heteša, J., Všetičková, L., Marvan, P., Sedláček, P. (2011): Vliv rybníků na vodní ekosystémy recipientů jižní Moravy. VTEI, 2011, roč. 53, č. 1/2011, s. . ISSN 0322-8916.
Všetičková, L., Adámek, Z., Rozkošný, M., Sedláček, P. (2012): Effects of semi-intensive carp pond farming on discharged water quality. ACTA ICHTHYOLOGICA ET PISCATORIA, 2012, roč. 42, č. 3, s. . ISSN 1734-1515.
Wener, B. (2011): Obnova zahrad v Polsku – vybrané příklady. In: sborník konference „Historické zahrady Kroměříž 2011“. Kroměříž: Klub UNESCO. 2011, pp. 43-44.

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Souhrn
Vodní prvky představují významnou součást prostředí kulturních památek a památkových zón a rezervací. Pro plnění požadovaných funkcí, které mohou zahrnovat společenské, ale i environmentální funkce, je nutné, aby byly v odpovídajícím cílovém stavu. Tento stav zahrnuje jak stavebně – technický stav, tak i kvalitativní stav. Článek prezentuje metodický přístup k popisu obou stavů a k hodnocení míry ohrožení a možné negativní změny. Uvedeny jsou výsledky průzkumů a hodnocení pro vodní prvky českých památek UNESCO.

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WATER QUALITY ASSESSMENT AS A PRE-REQUISITE FOR SUCCESSFUL DEVELOPMENT OF THE RECREATIONAL AREA. CASE STUDY OF THE HORNÁD BASIN (SLOVAKIA)

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Abstract
This study outlines the aspects and ways of assessing water quality in terms of tourism as one of the conditions for successful recreation development. The case study presents an example of the assessment of the surface water quality in the Hornád basin in terms of tourism. The surface water quality has been evaluated in 10 sampling profiles on the river Hornád and water reservoirs Ružín and Palcmanská Maša for the period 2010 - 2015, potentially toxic elements for the period 1995 - 2015. Evaluated had been selected indicators of surface water quality - general indicators, non-synthetic substances, synthetic substances, hydrological and biological indicators. According to valid legislative norms for the evaluation of surface water, data had been statistically processed and evaluated water quality and trends for the period. Overall evaluation provides a comprehensive picture of the quality of surface water in the evaluated area from the point of tourism, in relation to fishing tourism, swimming water quality and health risks.

Key words: surface water quality, Hornád basin, water reservoirs Ružín, heavy metal contamination, tourism

Introduction

The quality of surface waters and water reservoirs is an important condition for the successful development of recreational areas. Water of natural sites must not pose health risks in recreational activities such as bathing, water sports and fishing.

Fishing tourism

Water quality has a significant impact on fishing tourism from two perspectives: the occurrence and reproduction of fish, i.e. quality and quantity of the fish population and the contamination of fish with pollutants as a health risk (Koščová N., 2016). The basic condition of the development of fishing tourism are factors of the aquatic environment that affect the amount, quality and species composition of the fish population (Vrana B.et al., 2012). Significant factors are the amount of oxygen in water, water temperature, pH, amount and type of chemicals in water (Rajzák P. et al., 2002). Environmental contamination by pollutants can disrupt aquatic ecosystems, cause habitat loss and reduce biodiversity. It also has a significant impact on the life and reproduction of fish, which is reflected in the damage and death of the fish. Ammoniacal nitrogen and nitrite nitrogen are toxic when limiting values are exceeded (Vrana B.et al., 2012). Necessary for fish life is soluble oxygen in waters whose content decreases when the sinus is crossed. Fish gills damage aluminium. The most toxic substances are heavy metals and POPs (Koščová M., 2007). They damage fish organs, reduce fish vitality, coordinate disturbances, damage to gills, skin, plugs, growth and reproduction disorders (Košuth P., 1992).
From the point of human and his health, pollution of the environment with chemicals and their occurrence in fish is significant. Among the most dangerous pollutants are

heavy metals and persistent organic pollutants (POPs) for their properties such as accumulation in the environment, bioaccumulation, food chain contamination, toxicity and persistence. They may be in the environment for a long period (long after) after the source of the pollution has been removed. Their occurrence in the aquatic environment is a serious problem because the fish can concentrate them in amounts of 10^3 - 10^6 times higher than the quantity in water (Rajzák P. et al., 2002; (Koščová M., 2007). When exceeding the legislative standards for these chemicals in a given location, consumption of fish from contaminated areas could have a negative impact on the health of the consumer. From the point of fisheries, fishing and catching is recommended in polluted and risky areas (Andreji J. et al., 2009).

Swimming and water sports

To the unsatisfactory factors belong physicochemical indicators - colour, transparency, biological - cyanobacteria and microbiological - enterococci, coliform bacteria and Escherichia coli (Rovný I., 2008). Negative is in particular the occurrence of so-called Water blooms and faecal water pollution. Microbiological indicators are most severely monitored in water. The source of the disease and its transmission to humans can be infected human or faecal water pollution. Biological risks are mainly caused by the replicated cyanobacteria that cause the occurrence of the so called Water flower. The water is cloudy, smelly and unsuitable for swimming. Cyanobacteria in the water release cyanotoxins, which can cause allergic reactions, skin and mucous membrane irritation, conjunctival inflammation, digestive disorders, diarrhoea, respiratory problems (Holíková J., 2008). Therefore, the monitoring of the quality of natural bathing water is intended to prevent the occurrence of possible health risks.

As a condition for the successful development of a recreational area is health-friendly water, it is essential to know the quality of water and to monitor and analyse its developmental trends.

Methods

The assessment of water quality in the Hornád river basin in terms of tourism was done by analysing selected indicators of surface water quality in the outlets. We have evaluated the general requirements for surface water quality, bathing water quality and contamination of fish with pollutants (Koščová N., 2016).

The quality of surface water in the Hornád basin was assessed on the basis of the database and documentation of the Slovak Water Management Enterprise, which monitors the quality of surface water in Slovakia. We have evaluated the water quality at the points of delivery on the Hornád river, the floods of Ružín WR, the WR Ružín and the WR Palcmanská Maša. Altogether 10 despatch points were evaluated, from the upper stream of Hornád to the border with the Republic of Hungary. Among a quality indicators, the general indicators, non-synthetic substances, synthetic substances, hydrobiological and microbiological indicators were evaluated. The results of analyzes have been statistically processed for the period 2010 - 2015 (selected indicators for the period 1995 - 2015). We have evaluated the quality of surface water according to the SR Government Regulation no. 269/2010 Coll. Standards for water quality are defined as annual average concentrations and maximum permissible concentrations as the environmental quality standards established at European level. For the water quality assessment, the measured values in the monitoring are statistically processed as annual arithmetic averages, the 90th percentile values and are compared with the established limit values.

The quality of bathing water is monitored by the Public Health Authority of the Slovak Republic. From this point of view, the WR Ružín and WR Palcmanská Maša were evaluated in the monitored area. Other water areas of the Hornád river basin are not monitored as bathing waters. The evaluation of water reservoirs was carried out during the period 2009 - 2015 according to the SR Government Regulation no. 87/2008 Coll. about the requirements of natural swimming pools on the basis of data from the annual reports of the Public Health Authority of the Slovak Republic.
Pollutants in fish in the water reservoir Ružín and inflows - heavy metals and PCBs were evaluated on the basis of data provided by the Department of Veterinary Medicine in Košice. Heavy metals in fish were assessed according to the Decree of the Ministry of Health of the SR no. 2/1994 Coll. and PCBs according to the Decree of the Ministry of Agriculture of the Slovak Republic and the Ministry of Health of the Slovak Republic no. 18558/2006-SL.
Based on legislative requirements, we have statistically processed a data files for selected indicators and sample profiles, compared with the limit values and evaluated water quality and development trends in the monitored period (Koščová N., 2016).

Results and discussion
Based on the results of surface water quality analyses we have been monitoring the development of water in the Hornád basin and we have also evaluated the current status of water quality in the monitored area. Overall, we can see a good condition in general indicators of water quality. The water quality requirements do not meet the indicators - synthetic substances, microbiological indicators and in some cases also hydrobiological indicators.
From the point of fishing the entire catchment area of Hornád, mainly the recreation area of the Ružín water reservoir, is used.
Fishing tourism and fishing is affected by sources of pollution and contamination in the area that affect the quality of water suitable for life and reproduction of fish and the consumption of fish for human health. The condition for fishing is a healthy fish population that depends on water quality. From this point of view, the general water quality indicators were evaluated. We have evaluated 9 parameters - soluble oxygen, biological oxygen consumption, chemical oxygen demand, pH, ammoniacal nitrogen, nitrite nitrogen, nitrate nitrogen, total phosphorus, and total nitrogen. The values found were the norm in most analyzes. Limit values were exceeded only for nitrite nitrogen. Values of the general water quality indicators currently indicate good conditions for aquatic ecosystems and the fish population, a basic condition for the development of fishing tourism. The problem of heavy metal contamination is a problem of mining and metallurgical activity in the past, especially in the areas of Central Spiš. During the period of mining and metallurgical operations, discharged waste water had a toxic effect on fish life and significantly reduced the fish population in the area (Košuth P., 1992). After closure, the situation improved, which also had a beneficial impact on the fish population (Rajzák P. et al., 2002). However, the risk of pollutants (especially heavy metals) remained in the body of fish for human health when consumed.
The most contaminated environmental compartments include sediments of watercourses and, in particular, the Ružín water reservoir. High concentrations of metals in the sediment also affect their increased occurrence in water, which was also observed during the monitoring and evaluation of the water of the Ružín water reservoir and its inflows. The water contains Zn, Cu, Hg, Cd, As, Cr, Ni, Pb, Fe, Mn. The most frequent exceedances of the maximum concentration range are Zn, Cu

and Hg (Tab. 1 – 3). The highest concentrations of heavy metals during the 21 year period were recorded in the '90s and overall highest measured values were: Cu 100.7 mg /l (91 times more than the permitted annual average), 936.1 mg Zn / l (120 times more), Hg 4 µg / l (80 times more), Cd 7.1 µg / l (89 times more), Ni 63.1 µg / l (3 times more), Cr 34 µg / l (4 times more), As 71.9 µg / l (9.5 times more). By stopping the activities of mining companies (Smolník, Rudňany, Slovinky) we record the long-term decreasing trend of the development of heavy metal contamination. Development trends are showing a significant decrease in Hg, Cd, As, Cr and Ni. The concentration of As, Cr and Ni currently does not exceed the limit values. Increased concentrations exceeding the limit values are currently observed for Zn (Tab. 1) and Cu (Tab. 2), less Hg (Tab. 3) and Cd (Tab. 4). The copper and zinc content has decreased over the past, but has long overdue exceedances. From the monitored sites, the highest concentrations are located in Hornád, Hnilec and Ružín water reservoirs.

The industrial area of Košíc also causes pollution of the lower stream of the Hornád river. In this area, Pb, Hg, Ni, As, Cu, Zn, Cd are presented in water. Abnormal values occur at the border with Hungary, where the limits of Cu, Zn, CD and Hg are exceeded. In the water tank Palcmanská Maša, the same heavy metal occurs as in the entire catchment area. Currently, there are over-limit values of Cd, sometimes Cu and Zn.

Comprehensive research focused on the contamination of watercourses and water reservoirs Ružín and their sediments in the area was carried out by Bobro et al. (2006), Brehuv et al. (2005). The results demonstrated the high degree of contamination of Cu, Zn, Hg, Ni, Mn and high exceedance, but also the occurrence of As, Pb, Al, Fe, Co and Cr was found. At present, the research is focused on their mobility and bio-availability (Petrilakova A. et al., 2014; Šestinová O. et al., 2016). High bioavailability was observed for Cu, Hg, Pb. The bioavailability of metals in sediments was evaluated in the following order: Cu > Hg > Pb > Cd > Zn > Ni > Cr > Sb (Šestinová O. et al., 2016). This also means the possible contamination of aquatic organisms, especially fish (Košuth P., 1992; Rajzák P. et al., 2002; Brázová T. et al., 2012).

The contamination is associated with an increased content of heavy metals in fish. The research results (Tab. 5) from 1990 to 1992 (mining operations) showed that only 30.7% of fish were fit for consumption according to the applicable hygiene limits (Košuth P., 1992). Over the 23 years of research, the situation has improved. Except for Zn and Cu, there was a significant decrease in heavy metals in free water. But even so, heavy metals remain in environmental compartments, in sediments and constitute a mobile reservoir of these pollutants. Recent research has still documented the content of metals in fish. Brázová et al. (2012) carried out research on heavy metals in fish (Perca fluviatilis) during the period 2009 - 2010. In the body of fish, heavy metals were analysed in the following order: Zn > Cu > Mn > Hg > As > Cr > Cd > Ni > Pb. Zn and Cu in fish are represented at the highest concentrations, reflecting their current increased water content, which we have observed in assessing development trends. As regards human health, the concentration of Hg in fish muscle exceeded more than twice the limit value. The results also show the decreasing content of heavy metals and the recovery of the water tank. From the point of view of fishing and consumption of fish, the fact is that heavy metals are deposited mainly in organs, in the muscles are smaller amounts. Despite the reduction in the heavy metal content in the fish body, fish as food in this area remain at risk. Although fishing is allowed, the recommended method should be "catch and drop" (Koščová N., 2016). As monitoring of fish is not carried out,

regular monitoring of fish would be necessary, especially in important fishing recreational areas - Ružín and Palcmanská Maša.

From the point of view of fishing tourism and the content of toxic substances and elements in the body of fish, the assessment of water quality is a significant indicator of synthetic substances. Synthetic substances as PCB, DDT, HCB, PAH and pesticides - aldrin, dieldrin, endrin and isodrin were monitored. In the past, the over-limit content of synthetic substances, especially PCBs, has been recorded in the monitored area. Synthetic substances have been monitored irregularly by the year of 2010, in recent years monitoring has been rare. Therefore, it is not possible to actually assess the situation. The results show an increased content of PCBs in the river basin, which exceeds the limit standards in every supervised area. A downward trend was recorded. A similar trend was also noted with the DDT indicators, which is related to the ban on their application. Evaluated substances belong to POPs, they accumulate in the body of fish and pose a health risk. For these reasons, regular monitoring of the toxic substances and elements of the fish and the recommended method of “catching and dropping” would be needed.

Hydrobiological and microbiological indicators of water quality are important in terms of health risks in bathing and water sports. The biological parameters are monitored for chlorophyll-a in connection with the growth of cyanobacteria. Elevated values occur sporadically depending on climatic factors.

The long run, reduced microbiological water quality is recorded. We evaluated the results of the microbiological analyzes between 2005 and 2015. During this period, microbiological indicators were regularly monitored only in Hornád near the border with Hungary. Monitoring was not carried out in Ružín in the monitored period. The results of the previous assessment point to a significant microbial contamination of the Ružín water reservoir (Koščová M. et al, 2007). Other sampling points are monitored sporadically. Analysis has shown exceeding the limit concentrations of fecal bacteria, mainly intestinal enterococci and coliform bacteria. Abnormal values are recorded in the Hornád river at the border with Hungary (Tab. 6). This indicates the fecal pollution of the Hornád basin. The source of pollution in the area is missing sewerage, sewage treatment plants, agriculture. In terms of tourism, faecal pollution poses potential health risks in bathing and water sports. It is necessary to take measures to improve the situation by the competent authorities. As a result of health risks, it would be necessary to monitor microbiological indicators on a regular basis at more frequent collection points.

In terms of recreation it is important to monitor (evaluate) hydrological and microbiological indicators in the Ružín and Palcmanská Maša reservoirs. The quality of bathing water is monitored during the summer season of the Public Health Authority of the Slovak Republic. The Ružín - eastern part of the Košice district is currently included in the category of bathing water suitable for bathing. Due to recurrent faecal contamination, it is not recommended to bathe in Ružín - western part, belonging to the district of Gelnica. In this site, sporadic chlorophyll-a concentration is also sporadic, indicating the cross-linking of the sinus and the associated risks. Palcmanská Maša is not regularly monitored, so it is not included in the list of waters suitable for swimming. The current status of bathing water quality can be found on the website of the Public Health Authority of the Slovak Republic. The information system shows the current state of bathing water in the monitored localities during the summer season.

Tab. 1: Concentration of Zn in the surface water of the Ružín reservoir and its inflows

Sampling profiles	[µg/l]	1995	1996	1997	1998	1999	2000	2001	2010	2011	2012	2013	2014	2015
Hornád	$\bar{x}$	134,3	350,1	287,4	242,7	164,0	118,3	175,8	-	-	15,80	14,21	12,11	8,09
Hnilec	$\bar{x}$	294,0	478,2	228,2	167,9	226,3	144,4	113,1	95,75	-	-	-	-	-
Ružín	$\bar{x}$	-	-	-	-	-	-	-			12,30	-	10,63	7,03
Annual average: 7,80 µg/l														

P90 – percentile 90 $\bar{x}$ - annual average

Tab. 2: Concentration of Cu in the surface water of the Ružín reservoir and its inflows í

Sampling profiles	[µg/l]	1995	1996	1997	1998	1999	2000	2001	2010	2011	2012	2013	2014	2015
Hornád	$\bar{x}$	29,8	64,7	35,0	9,72	7,89	12,6	23,2	-	-	6,06	3,14	5,95	1,95
Hnilec	$\bar{x}$	-	-	19,5	34,3	40,9	26,0	18,0	34,8	-	-	11,5	5,0	-
Ružín	$\bar{x}$	-	-	-	-	-	7,25	17,8	8,97	-	6,85	-	3,99	1,91
Annual average: 1,10 µg/l														

P90 – percentile 90 $\bar{x}$ - annual average

Tab. 3: Concentration of Hg in the surface water of the Ružín reservoir and its inflows

Sampling profiles	[µg/l]	1995	1996	1997	1998	1999	2000	2001	2010	2011	2012	2013	2014	2015
Hornád	$\bar{x}$	0,45	0,17	0,61	0,16	0,03	0,05	0,04	-	0,05	0,05	0,10	0,03	0,06
	P90	0,98	0,46	0,94	0,50	0,09	0,05	0,11	-	0,05	0,05	0,21	0,05	0,12
Hnilec	$\bar{x}$	0,68	0,24	0,95	0,03	0,54	0,18	0,05	0,05	-	-	0,07	0,00	-
	P90	1,95	0,61	2,25	0,06	1,18	0,45	0,13	0,06	-	-	0,07	0,00	-
Ružín	$\bar{x}$	-	-	-	-	-	0,05	0,07	0,07	-	-	-	-	-
	P90	-	-	-	-	-	0,05	0,17	0,11	-	-	-	-	-
Annual average: 0,050 µg/l Maximum permitted concentration (P90): 0,070 µg/l														

P90 – percentile 90 $\bar{x}$ - annual average

Tab. 4: Concentration of Cd in the surface water of the Ružín reservoir and its inflows

Sampling profiles	[µg/l]	1995	1996	1997	1998	1999	2000	2001	2010	2011	2012	2013	2014	2015
Hornád	$\bar{x}$	1,53	1,75	0,98	1,13	0,64	0,51	0,40	-	0,23	0,41	0,35	0,16	0,26
	P90	5,61	5,78	1,60	1,87	0,84	1,16	0,66	-	0,27	0,75	0,71	0,45	0,62
Hnilec	$\bar{x}$	0,78	3,50	2,70	1,31	1,50	0,67	0,25	0,59	-	-	0,23	1,00	-
	P90	1,20	5,16	5,40	2,92	3,37	1,12	0,43	1,16	-	-	0,35	0,00	-
Ružín	$\bar{x}$	-	-	-	-	-	0,60	0,30	0,25	-	0,19	-	0,25	0,17
	P90	-	-	-	-	-	1,09	0,54	0,32	-	0,19	-	0,54	0,28
Annual average: 0,080 µg/l Maximum permitted concentration (P90): 0,0450 µg/l														

P90 – percentile 90 $\bar{x}$ - annual average

Tab. 5: Fish Contamination of Central Spiš, 1990 – 1992 (Košuth P., 1992)

[mg/l]	Cu	Pb	Cd	Zn	Ni	Hg	Mn	PCB
Hornád								
Thymallus	0,443	0,385	0,030	5,453	**0,500**	0,189	0,335	**5,510**
Barbatula	6,700	0,133	0,023	-	-	-	-	-
Salmo	0,440	0,320	0,030	18,880	**1,090**	0,087	0,490	**2,410**
Gobio	**22,000**	0,810	0,041	-	-	-	-	-
Leuciscus	0,750	0,640	0,090	24,610	**3,790**	**1,342**	4,670	**12,600**
Perca	0,400	0,580	0,060	13,300	**2,950**	**2,041**	1,130	-
Rutilus	0,480	0,490	0,090	17,990	**2,920**	**0,747**	1,050	-
Hnilec								
Leuciscus	0,410	0,660	**0,130**	30,390	**4,330**	0,358	1,250	**17,900**
Perca	0,350	0,590	0,070	8,370	**3,100**	0,204	4,050	-
Rutilus	0,580	0,520	**0,110**	24,280	**2,760**	**0,931**	0,910	**10,900**
Ružín								
Leuciscus	7,071	0,229	0,033	-	-	-	-	-
Perca	4,214	0,722	0,009	-	-	-	-	-
Perca	0,140	0,100	0,010	3,730	**1,520**	**2,264**	0,480	-

Rutilus	0,160	0,100	0,003	4,870	0,150	**0,531**	0,210	-
Anguilla	**14,107**	**1,144**	0,080	-	-	-	-	-
Limit values [mg/l]	**10**	**1**	**0,1**	**50**	**0,5**	**0,2 - 0,6**	**-**	**0,2 - 0,3**

Tab. 6: Exceeded limit values for microbiological indicators in the Hornd Basin: sampling profile Hornád - Hidasnémeti

Sampling profiles	[KTJ/ml]	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coliform bacteria	(Maximum permitted concentration: 100 KTJ/ml)											
Hornád - Hidasnémeti	$\bar{x}$	228	72	-	150	-	-	794	922	142	520	27
	P90	**580**	**132**	-	**150**	-	-	**3090**	**2657**	**313**	**1650**	61
Intestinal enterococci	(Maximum permitted concentration: 10 KTJ/ml)											
Hornád - Hidasnémeti	$\bar{x}$	1808	2480	2153	1340	1048	3537	1976	-	-	-	-
	P90	**3965**	**5650**	**4995**	**2100**	**2350**	**8875**	**2377**	-	-	-	-

Conclusion

Monitoring of surface water quality and risk prevention is an important condition for the protection of the health and well-being of tourists.

It is necessary to carry out a thorough monitoring of the quality of the surface water mainly of the recreational areas. Expand regular monitoring of bathing water in natural sites (Palcmanská Maša) and increase the number of monitored collection points (Ružín). It is important to introduce monitoring of toxic fish that does not take place in Slovakia. In view of the persistent contamination of certain regions with pollutants, it would be appropriate to re-evaluate the methods of fishing in these areas for the "catch and drop" method.

References

Andreji, J., Stráňai, I., Tóth, T. (2009): Heavy metal concentrations in fish muscle and bottom sediments from the Malé Zálužie pond. In: Acta fytotechnica et zootechnica, No.1, p. 13 – 16.

Brázová, T. et al. (2012): Pearch and its parasites as heavy metal biomonitors in a freshwater environment: The case study of the Ružín water reservoir, Slovakia. In: Sensors, 12, p. 3068 – 3081.

Brehuv, J. et al. (2005): Influence of the old mining loads on the contamination of streams, flows in the Water-work Reservoir “Ružín I” in 2004 year by the select ed elements. In: Acta Montanistica Slovaca, Vol. 10, p. 322 – 328.

Bobro, M. et al. (2006): Wastes after mining and metallurgical operations in the Ružín reservoir. In: Acta Metallurgica Slovaca, 12, p. 26 - 32.

Holíková, J. (2008): Human Health Requirements for Water Quality for Bathing. In: Životné prostredie, 2008, Vol. 42, No. 4, p. 180 – 184.

Koščová, M. (2007): Environmentalistika. TU Košice, 93 p.

Koščová, M. et al. (2007): Microbial contamination of the Ruzin dam. In: Acta Mechanica Slovaca, 4-B, p. 112-116.

Koščová, N. (2016): Water quality assessment of the Hornád basin from tourism aspect (Thesis). TU Košice, 126 p.

Košuth, P. (1992): Impact of pollution of watercourses in the central Spiš area on the state of health of fish. Partial Project Management: Solving the Environmental Situation of Middle Spiš. Košice, 1992. 20 p.

Petrilaková, A. et al. (2014): Study of heavy metals stratification in sediment in Reservoir Ruzin (Slovakia). In: Pollack Periodica, 9, 3, p. 35 - 42.

Public Health Authority of the Slovak Republic: Report about observing the hygienic situation on natural water areas and artificial swimming pools during the 2009 - 2015 bathing season. Bratislava.

Public Health Authority of the Slovak Republic. Bathing water. [online]. Available at: <http://www.uvzsr.sk>

Rajzák, P., Košuth, P. et al. (2002): Fish in Slovak waters in toxicological monitoring of SEPS of SR. In: Slov.vet.čas., Vol. 27, No. 2, p. 88 - 94.

Rovný I. (2008): Water Quality in Recreational Facilities in Slovakia. In: Životné prostredie, Vol. 42, No. 4, p. 176 - 179.

Slovak Water Management Enterprise, OZ Košice. Internal materials and database.

Šestinová, O. et al. (2015): Study of metal mibility and phytotoxicity in botton sediment that have been influenced by former mining activities in Eastern Slovakia. In: Environmental Earth Sciences, 74, 7, p. 6017 – 6025.

Vrana B.et al. (2012): Harmonization and evaluation of sampling techniques for the monitoring of priority substances in the aquatic environment. In: Hydrochémia, p. 41 - 50.

Souhrn
Kvalita povrchových vod toků a vodních nádrží je důležitou podmínkou úspěšného rozvoje rekreačních oblastí. Hodnocení kvality vody v povodí Hornádu z hlediska turismu bylo realizováno analýzou vybraných ukazatelů kvality povrchové vody v stanovených odběrných místech řeky Hornád, vodní nádrže Ružín a Palcmanská Maše za období 1995 - 2015. Celkem bylo hodnoceno 10 odběrných míst, od horního toku Hornádu až po hranici s Maďarskou republikou. Vyhodnocovány byly všeobecné požadavky na kvalitu povrchových vod, kvalitu vody na koupání a kontaminace ryb znečišťujícími látkami.
Celkově můžeme konstatovat dobrý stav v obecných ukazatelích kvality vody. Hodnoty těchto ukazatelů indikují dobré podmínky i pro vodní ekosystémy, jejich biodiverzitu a populaci, což je základní podmínkou rozvoje rybářského turismu. Požadavky na kvalitu vody nesplňují ukazatele - syntetické látky, mikrobiologické ukazatele a v některých případech i hydrobiologický ukazatele. Problematická je kontaminace oblasti těžkými kovy jako pozůstatek hornické a hutnické činnosti v minulosti, hlavně v lokalitách Středního Spiše. Ve vodách se nachází Zn, Cu, Hg, Cd, As, Cr, Ni, Pb, Fe, Mn. Nejčastěji překročení nejvyšší přípustné koncentrace vykazují Zn, Cu a Hg. V minulosti byl zaznamenán i nadlimitní obsah syntetických látek, hlavně PCB. V současnosti se monitoring neprovádí. Z těchto důvodů by byl zapotřebí pravidelný monitoring ryb na toxické prvky a doporučeným způsobem rybolovu metoda "chyť a pusť". Dlouhodobě je zaznamenáno i fekální znečištění a snížená mikrobiologická kvalita vody. Zdrojem znečištění v oblasti je chybějící kanalizace, nedostatečně vyčištěné vody z čistírny odpadních vod a zemědělství. Z hlediska turismu fekální znečištění představuje možná zdravotní rizika při koupání a vodních sportech. Kvalita vody ke koupání je sledována během letní turistické sezóny ÚVZ SR ve vodních nádržích, v povodí Hornádu - v Ružíne a Palcmanské Maši. Do kategorie vod vhodných ke koupání je v současnosti zařazena lokalita Ružín patřící do okresu Košice - okolí. V důsledku opakujícího se fekálního znečištění, nedoporučuje se koupat v lokalitě Ružín - západní část, patřící do okresu Gelnica. Palcmanská Maša není pravidelně sledována, proto nemá status přírodního koupaliště. V souvislosti s koupáním je třeba se informovat o aktuálním stavu kvality vody ke koupání na webových stránkách Úřad veřejného zdravotnictví Slovenské republiky (ÚVZ SR).
Sledování kvality povrchových vod a následným předcházením rizikovým situacím je důležitou podmínkou ochrany zdraví lidí rekreujících se u vody a celkové pohody rekreanty.

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WHEELCHAIR ACCESSIBLE TRAILS IN THE TRAINING FOREST ENTERPRISE MASARYK FOREST KŘTINY

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Abstract
The paper focuses on the issue of forest access for people who are disabled, especially wheelchair users. It describes the general requirements for trails for wheelchair users, and the parameters that affect the selection of suitable sites. These are especially the trail slopes, obstacles on the roads, and their surfaces. Further, the issues that need to be tackled when designing wheelchair accessible trails are mentioned. Possible solutions are presented at the selected territory of the Training Forest Enterprise Masaryk Forest Křtiny, where forest roads are used for the trails. The paper discusses the accessibility of the location and the attractiveness of the landscape and presents the proposal for the necessary modifications and measures to take. The paper also includes options of promotion of trails for disabled people already available.

Key words: wheelchair accessible trails, short-term recreation, road parameters

Introduction

Persons with disabilities constitute a group of people who have more complicated living conditions because of their handicaps. However, these people have the same needs, they want to take trips and relax in the countryside as the others. The issue of forest accessibility for persons with reduced mobility has been discussed little in the Czech Republic and it deserves more attention. As reported by Rollová (2015), it is necessary to promote the methods of universal designing, which take into account the demands of a broad range of users.

Entering a forest and staying in a forest environment is allowed by act no. 288/1995 Coll., on forests amending and supplementing some acts (forest act), as well as e.g. act no. 114/1992 Coll., on nature and landscape protection. The number of people with disabilities is huge. However, they are a very diverse group, who vary in type and scope of their physical disability. The situation is especially troublesome for wheelchair users, who are restricted with plenty of obstacles when moving in the countryside. This issue has been dealt with by Jakubisová (2013, 2016). We have to attempt to eliminate these obstacles and look for possible solutions.

Lundell (2005) listed basic parameters for designing trails for disabled people in the forest in the conditions of Sweden. It is necessary to know the requirements and parameters of wheelchair users to be able to design barrier-free trails where the tourist destination will be the natural environment. The investigation into the necessary requirements and the determination of the parameters for designing forest trails were the subject of a project, funded by the Visegrad fund, whose output is a publication focused on the issue in the Czech Republic, Poland and Slovakia (Fialová et al., 2015). The project included a questionnaire survey done among

wheelchair users. Janeczko (2016, 2017) presented a comparison of the data acquired and a statistical evaluation of some important parameters of forest trails in these countries.
Social tourism, or tourism for all, is one of leisure activities of people with disabilities and it is becoming increasingly popular in the Czech Republic. The recreational function is the most marked in suburban forests, which are the daily target of many visitors. Therefore, we have proposed an IGA project (Internal Grant Agency project), which is implemented in the territory of Training Forest Enterprise Masaryk Forest Křtiny, which is a purpose-built facility of the Faculty of Forestry and Wood Technology and is located in the vicinity of Brno. The aim of the project is to explore the possible use of the forest road network for the wheelchair accessible recreation. This comprises the identification of suitable forest roads and designing of trails for wheelchairs. The aim is to design trails where a wheelchair user could move also independently, without a need for assistance.

Materials and methods
The parameters of the individual types of forest roads are described in the valid standard ČSN 73 6108 Forest transport network. Due to the fact that forest roads may be linked to field roads, also the requirements of standard ČSN 73 6109, Designing field roads, need to be considered. When designing wheelchair accessible trails in forests, decree of the Ministry of Regional Development no. 398/2009, on general technical requirements barrier-free use of constructions, has to be respected.
First, only reinforced roads with suitable slopes within the Training Forest Enterprise Masaryk Forest Křtiny were selected using a map. The map of slopes was created in ArcGIS from the digital terrain model gained by airborne laser scanning. The map of road network uses the database of the Training Forest Enterprise, is cleared and modified based on orthophotomaps.
A field survey followed. The selected roads were investigated as regards their suitability for short-term recreation of wheelchair users, who could move along the trail alone, or with assistance. The data on the longitudinal slope shown in the map were verified and the road surfaces and widths, the degree of damage (ruts, surface damage, potholes, etc.) and barriers (stones, open top culverts, gates, etc.) were detected.
Further, the roads selected as suitable for persons with reduced mobility were investigated and evaluated as regards the presence of pleasant views, wells, water bodies, memorials, etc.
When selecting wheelchair accessible trails it is also necessary to consider the starting place and the destinations. The starting place needs to have good parking facilities or a functional linking to public transport, or possibly a direct access for persons with reduced mobility.

Results
One of the selected locations is an area near village Bukovina leading to Arboretum Křtiny (see map, Fig. 1). The map shows the mean slopes, but in reality we based the selection on a more detailed map, where slopes are shown each 10 metres. We selected the roads with the mean slope not bigger than 8%, as the maximum longitudinal slope of a wheelchair accessible trail can be a ratio of 1:12 (8.33%).
The surface of the selected forest roads is reinforced with an unbound layer of aggregate, in some sections there is mechanically reinforced aggregate; there is also a part with asphalt, which is preferred by wheelchair users.

Due to the slopes in the area, an ideal circuit could not be formed; however, there are three possible starting places. When starting at the Arboretum Křtiny, there are parking spaces (see Fig. 2) as well as a bus stop; however, the trail leads only there and back, along the same road. The reward for a slight incline can be the relaxation point about 700 m distant at the first water body and K. J. Schindler's well at the second water body with nicely maintained surroundings (Fig. 3). The start from other places (near Birch Alley or at the gamekeeper's lodge at the Proklest Road) will be more demanding — this will require the construction of parking spaces, as well as an arrangement for wheelchair users to get around the gate, which currently cannot be passed in a wheelchair (Fig. 4). These starting places are especially suitable for smaller slopes of planned trails and it is possible to create a small circuit in part of these roads.

Average Slopes on Forest Roads Near Bukovina

Fig. 1: Map of Bukovina Training Forest Enterprise Masaryk Forest Křtiny – road slopes

Fig. 2: Parking space at the Arboretum Křtiny (Fialová, 2016)

Fig. 3: Small K. J. Schindler's water body - a suitable place for relaxation (Fialová, 2016)

Fig. 4: Barrier for wheelchair users – a gate which cannot be overcome (Fialová, 2016)

Discussion

After wheelchair accessible trails are created, it is necessary to get sufficient promotion on the Internet. Information on accessibility is crucial for wheelchair users when deciding on a trip. The information must be sufficiently detailed to allow everybody to evaluate with certainty whether he or she can actually go to the place, if they can go alone or assistance will be necessary. In addition to the description of the trail, other accompanying information is needed, e.g. the distance of a public transport stop, availability of the parking space, refreshments, accessibility and

distance of a barrier-free WC, etc. as for example Ondrejka (2015) described in the article. The importance of nature conservation and taking it into account is important as well (Zeleňáková, 2016).
Another problem wheelchair users might face on forest roads is the possible collision with means of transport, in particular hauling machinery. For this reason, it would be appropriate to use the Internet for the information about potential timber harvest or other planned movement of heavy machinery at the place, in order to prevent potential collisions.

Conclusion
Wheelchair users are a group of people who face many restrictions when relaxing in the countryside. It is necessary to create such conditions in the forests that will allow them to go to forests and spend there time to regenerate, recreate or even educate. Wheelchair users are faced with barriers in the forest, such as gates, lateral drainage, unsuitable surface, etc., which make their stay and mainly movement in the forest difficult or even impossible. When selecting suitable roads, besides the slope, also the road surface is important. Asphalt surfaces are seen as the most appropriate, for their surface flatness, lesser risk of slippage, moving comfort, functionality and durability. As regards unbound structural layers of reinforcement, we can only recommend a layer of mechanically reinforced aggregate (unbound mixtures - type 1) with a maximum fraction size of 32 mm.

References
Fialová et al. (2015): Trails for disabled people in the V4 countries. 1.vyd. Ko- šice: Technická univerzita v Košiciach, 2015. 246 s. ISBN 978-80-553-2394-7.
Jakubisová, M. (2013): Touristic and educational polygon for visitors with disabilities in Protected Site Borová hora Arboretum of the Technical University in Zvolen. In Journal of landscape management. 2013. č. no. 1, s. 60-66. ISSN 1804-2821.
Jakubisová, M. (2016): Verification of technical parameters and experiences in access to touristic polygons for wheelchair people in Slovakia. In Public recreation and landscape protection - with nature hand in hand...: conference proceeding, 1st - 3rd May 2016, Křtiny. Brno: 2016, s. 282-287. ISBN 978-80-7509-408-7.
Janeczko, E. et al. (2016): Preferences of people with disabilities on wheelchairs in relation to forest trails for recreational in selected European countries. In Folia Forestalia Polonica. 2016. č. no. 3, s. 116-122. ISSN 0071-6677. International Visegrad Fund serial number 11510242.
Janeczko, E. et al. (2017): Preferencje niepełnosprawnych na wózkach inwalidzkich w zakresie rekreacji w lasach Polski i Republiki Czeskiej. Sylwan. 2017, 161(2), 170-176. ISSN 0039-7660. Dostupné z:
https://sylwan.lasy.gov.pl/apex/f?p=105:10:::NO::P10_NAZWA_PLIKU,P10_ARTYKUL:swiezy_plik,2016120
Lundell, Y. (2005): Access to the forests for disabled people. National Board of Forestry: Jönköping; 87. ISSN 1100-0295.
Ondrejka Harbulakova, V., Zelenakova, M., Vices, J. (2015): Evaluation of stressors from the human activities in Kosice city. 2015. In: Journal of Landscape Management. Vol. 6, no. 1 (2015), p. 72-80. - ISSN 1804-2821
Rollová, L. (2015): Univerzálne navrhovanie v krajinnom prostredí. In: Chodníky pre telesne postihnutých ľudí na vozíku v krajinách V4. Zvolen: Technická univerzita vo Zvolene, 2015. s. 140-147. ISBN 978-80-228-2757-7.

Zelenakova, M., Ondrejka Harbulakova, V. (2016): Quantitative overview of the EIA process in Slovakia. 2016. In: SEA/EIA 2016. - Banská Bystrica : SAŽP, 2016 S. 1-6. - ISBN 978-80-89503-46-9

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Souhrn
Příspěvek je zaměřen na problematiku zpřístupnění lesa handicapovaným lidem, především však lidem na vozíku. Vozíčkáři se v lese setkávají s bariérami, jako jsou závory, příčná odvodnění cest, nevhodný povrch apod., které jim pobyt v lese znemožňují. V příspěvku jsou popsány obecné požadavky na stezky pro lidi na vozíku a parametry, které ovlivňují výběr vhodné lokality. Jedná se zejména o sklony, terénní překážky nebo povrchy cest. Možnosti řešení jsou představeny na vytipovaném území ŠLP ML Křtiny, kde jsou pro stezky využity lesní odvozní cesty. Je zde rozebrána přístupnost lokality, atraktivnost území a návrh nezbytných úprav a opatření. Součástí článku jsou i možnosti propagace již realizovaných stezek pro handicapované lidi.

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Říkáme si zkrášlovači krajiny. Zabýváme se obnovou a zakládáním nových prvků zeleně v krajině nebo intravilánu. Při naší práci hraje prim selský rozum, poctivá práce a razíme heslo: „Obnovme biotop, vrátí se i druhy na něj vázané."

O naše zkušenosti získané v terénu při výsadbách se opíráme i během projekce. Umíme si tedy již od samotného nápadu vzniku nového prvku představit možná úskalí a tomu se přizpůsobujeme.

Našimi hlavními přednostmi jsou lidský přístup a cílení na konečný produkt, čímž je zlepšení stavu přírody a krajiny.

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