https://doi.org/10.17221/20/2018-JFS

Comparison of results of visitor arrival monitoring using regression analysis

Petra HLAVÁČKOVÁ, Hana SLOVÁČKOVÁ, David BŘEZINA, Jakub MICHAL*

Department of Forest and Wood Products Economics and Policy, Faculty of Forestry and Wood Technology, Mendel University in Brno, Brno, Czech Republic

**Corresponding author: hanka.slovackova@gmail.com*

Abstract

Hlaváčková P., Slováčková H., Březina D., Michal J. (2018): Comparison of results of visitor arrival monitoring using regression analysis. J. For. Sci., 64: 303–312.

Monitoring of visitor arrivals is one of the tools which help to ensure good-quality and suitable management of the respective area. This paper is aimed at the monitoring of visitor arrivals when the visitors are counted automatically using a field counting device, namely a pyroelectric sensor. In 2015, visitor arrival monitoring using a pyro sensor was conducted on the selected forest roads in the Křtiny Training Forest Enterprise of Masaryk Forest. Since this method should be employed in another project, it was necessary to find out whether the pyroelectric sensor is a reliable tool and whether it can be used for further research. The aim of this paper is to perform a regression analysis of the data collected at the selected site in order to determine whether the pyroelectric sensor provides relevant information. Two data sets acquired during the first week of the monitoring of visitor arrivals at the single site will be compared. The one set includes data obtained by automatic monitoring using the pyro sensor, the other set contains data gained by means of manual counting by students of the Faculty of Forestry and Wood Technology. Two directions of visitor flows were monitored – in and out. The data were statistically processed using the ADSTAT software. Results of the regression analysis show that the results of the visitor arrival monitoring carried out using a pyro sensor differ just slightly from those gained by manual counting.

Keywords: recreation; forest roads; economy; statistical processing; pyro sensor

Over several last decades, tourism has been the crucial factor in both social and economic regional development, which was noted for example by Lama and Sattar (2002), Hall et al. (2005), Banaš (2006), and Michopoulou and Buhalis (2013). Encouraging tourist activities has been an important part of regional development policies on a long-term basis (Telfer 2002). Nevertheless, tourism activities have a wide variety of very intensive impacts over a long-period (Telfer 2002; Barros et al. 2013; Daldeniz, Hampton 2013; Ivanov, Webster 2013; Tang, Abosedra 2014).

However, tourism is not just a disturbing element anymore. The society appreciates the benefits which the use of the territory brings to tourists, at the regional level in particular. From the economic point of view, the value of these benefits is represented by monetary amounts that each tourist is willing to pay for his visit here, in this region.

The global increase in recreational and tourist activities implies the need for research in visitor arrivals in the respective areas (Miller et al. 2017). The increasing number of tourists brings the necessity to establish so-called visitor arrival management. Basic tasks of the visitor arrival management should mainly include an elimination of negative effects related to tourism and establishing a sustainable use of the respective territory. Once

Supported by the Mendel University in Brno, Projects No. LDF_VT_2015010 and No. 2018004.

more detailed data on the recreational use of the territory have been obtained, they can be subjected to further analysis and used together with scientific and sociologic knowledge to establish an ecologically and economically sustainable management of the researched territory.

To establish a good-quality and suitable management, it is necessary to find out who is going to use the territory and how the first, as well as to what extent the environment is affected by tourism. This can be done by means of a complex visitor arrival monitoring. Generally, the goal of the visitor arrival monitoring is to provide basic information about the number of visitors together with information about the temporal variability of the visitor arrivals (Zahradník et al. 2012). Various methods of visitor arrival monitoring are employed to gain information about who uses the territory and to what extent. Examples can be found in Muhar et al. (2005), who dealt with various methods dividing them into direct and indirect ones.

These days, visitor arrival monitoring is mainly employed in protected areas (Cole 1989; Manning 2002; Muhar et al. 2005; Beunen et al. 2008; Wolf et al. 2012; Weaver, Lawton 2017). In the Czech Republic, it has been one of the main activities performed in the area of tourism by the administrations of large-scale protected areas over the last years (Bláha 2010; Kala, Salov 2010; Kos 2010). However, these methods may be used to monitor visitor arrivals in forests, too. For example, Kettler (1970), Volk (1992), Cessford and Muhar (2003), von Janowsky and Becker (2003), and Wolf et al. (2012) dealt with visitor arrival monitoring in forests.

Complex visitor arrival monitoring usually comprises three parts. These are uninterrupted counting of visitors by an automated device, regular physical counting, and a questionnaire survey.

This contribution is aimed at visitor arrival monitoring performed using automated visitor counting by a counting device, which allows acquiring basic information about the number of visitors and their characterization. Nowadays, four basic technologies are used to count visitors to a territory automatically: stepping pressure sensors, which act on the basis of a change in pressure; thermal sensors (pyroelectric sensors or pyro sensors) working on the principle of detecting a body temperature when a person passes by the sensor; magnetic counters which use magnetic response; and, finally, optical sensors, which act on the principle of optical beam interruption (Zahradník et al. 2012).

Within the scope of the project by the Internal Grant Agency of the Faculty of Forestry and Wood Technology of Mendel University in Brno, visitor arrival monitoring was conducted at selected forest roads in the Křtiny Training Forest Enterprise of Masaryk Forest (Křtiny TFE) in 2015 using a pyro sensor. The aim of this contribution is to find out whether the pyroelectric sensor provides relevant information by means of performing a regression analysis of the data obtained from the selected site. Two sets of data from the same site acquired between 9 a.m. and 5 p.m. during the first week of monitoring will be compared. The one set includes data obtained by means of the automatic monitoring using a pyro sensor, the other set contains data gained by means of manual counting carried out by students of the Faculty of Forestry and Wood Technology. Two directions of flows of visitors were monitored – in and out. The data were statistically processed using the ADSTAT software (Version 1.25, 1991).

MATERIAL AND METHODS

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). A similar definition can be found in the Vocabulary for Quality Management Systems (ČSN EN ISO 9000:2006). This vocabulary describes validation as a confirmation obtained by means of providing objective evidence that the measurement procedure/measurement system/product and so on can meet the requirements put on it.

Most often, validation is employed by various laboratories (Riley, Rosanske 1996) but it can be used to verify models in economics as well (Fagiolo et al. 2007).

Methodology

The process of validation as well as of regression diagnostics has been described by Meloun and Militký (2012). The procedure is divided into several steps: (*i*) model designing, (*ii*) preliminary data analysis, (*iii*) parameter estimates, (*iv*) basic statistical characteristics, (*v*) regression diagnostics, (*vi*) designing a refined model, (*vii*) model quality assessment.

The procedure will be described below in more details. Passages have been adopted from Meloun and Militký (2012); this quotation is not mentioned in the individual paragraphs.

Model designing. First, a regression model has to be designed, the linear regression model in this case, which can be expressed as follows (Eq. 1):

$$y = \beta_0 + \beta_1 x \quad (1)$$

where:

y – dependent variable,

β_0 – intercept,

β_1 – slope,

x – independent variable.

The following null hypothesis will be tested for this model: H_0: $\beta_0 = 0$, $\beta_1 = 1$.

Preliminary data analysis. The position and variability of the y, x variables will be assessed on the basis of the average and the standard deviation of values of each variable. The level of correlation between the variables will be assessed using the Pearson correlation coefficient.

Parameter estimates. Estimates of the parameters of the β_0 intercept and the β_1 slope will be defined using the least squares method (LSM). Student's t-test will show whether the intercept (absolute member) and the slope are statistically significant or not.

Basic statistical characteristics. It mainly deals with the following:

(*i*) Pearson correlation coefficient (R) – this will prove whether the designed linear regression model is statistically significant;

(*ii*) the coefficient of determination (D) – it shows how many percentage points fit the regression model and, thus, whether these points correspond to the linear model;

(*iii*) the mean squared prediction error (MEP) and Akaike information criterion (AIC) – these will determine which of the designed models is better. It should be the one which shows lower values of those quantities.

Regression diagnostic. It comprises tools and procedures for the interactive analysis of data, model, and method, which represent the components of the regression triplet. Conditions corresponding to the following components of the regression triplet must be met to find an acceptable model:

(*i*) criticism of the data: determines the suitability of the data for the designed model, sets the interval of the data, their variability, and presence of influential points. For example, a graph of the regression, an analysis of classic and other residuals or graphs of influential points can be used for this purpose;

(*ii*) criticism of the model: in the case of a single-dimension regression model, the model fit is assessed directly in the graph which contains the data and the model function course. The goal is to determine whether the line is acceptable and whether the course of the data is linear;

(*iii*) criticism of the method: the aim is to examine whether the basic assumptions of the LSM are met, under which the method will provide the best linear impartial estimates of the regression parameters. Above all, Fisher-Snedecor test for regression significance will be employed (which examines whether the designed model is significant), Scott's criterion of multicollinearity (although this is not significant with the single-dimension model), Cook-Weisberg test for heteroscedasticity (which proves whether the range of scattering of the residuals is not constant), Jarque-Bera test for normality of the residuals (in the case of classic residuals, it shows whether their distribution is Gaussian or not), Wald test for autocorrelation (showing whether there is any autocorrelation in the residues), and the binomial test (which proves that the sign of the classic residuals alternates sufficiently).

Designing a refined model. If any influential data points are found which could be eliminated, a new model will be designed upon their elimination and new estimates of the parameters of this model will be found. The model will be proved using the new statistical characteristics. If the values of MEP and AIC are lower than in the preceding model, the refined model can be considered better.

Model quality assessment. The model quality will be assessed by comparing the regression diagnostics, i.e. by assessing the regression triplet obtained from the linear model for the refined data with the outliers removed, using the method of weighted least squares.

The found refined model will be expressed by Eq. 1 and the interval estimate of the parameters of β_0 intercept and β_1 slope will be determined by Eqs 2 and 3:

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

where:

$t_{1-\frac{\alpha}{2}}(n-m)$ – Student's t-distribution quantile $(n - m)$ of degrees of freedom,

b_0 – estimator of the intercept parameters,

α – significance level,

n – number of experimental points,

m – number of model parameters,

D – coefficient of determination.

$$b_1 - t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_1)} \le \beta_1 \le b_1 + t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_1)} \qquad (3)$$

where:

b_1 – estimator of the slope parameters.

The Hradská forest road was selected as the area of interest. This forest road lies in the territory of the Křtiny TFE. The Křtiny TFE is a special-purpose facility of the Faculty of Forestry and Wood Technology of Mendel University in Brno.

The selected forest road is 4 m wide and its surface is made of bitumen. The road is used by hikers, cyclists, and, to a limited extent, by vehicles for forest works. Bike path No. 5119 from Nový Hrad to Jedovnice and a red hiking signage lead along this road. During the period from 1 July to 30 November, 8,643 visitors arrived at the forest road; the day with most arrivals was Saturday. Features of the Hradská site are shown in Fig. 1.

The visitor arrival monitoring was performed by a contracted company Partnerství, o. p. s. The company carried out the counting using a sensor, which was complemented by physical calibration counting performed by the Faculty of Forestry and Wood Technology (FFWT) students at the target counting profile.

Specifically, the automatic counter was the Pyro Box Compact type (Eco-counter, France). This device counts all users of the paths (hikers, cyclists, in-line skaters, etc.) without making differences in the user type. The counting is done on the principle of detecting differences in the temperatures of the human body and the environment. Since the counters employ two sensors, they can also distinguish the direction of the motion. The counters are battery charged and do not depend on any external power supply. Data are saved on an hourly basis. The counter can be installed on any column or tree stem.

The FFWT students noted down information about the visitor arrivals in the calibration form on an hourly basis, too. Subsequently, the data were transcribed into a table in Microsoft Office Excel (Version 2013).

The visitor arrival monitoring was performed at the selected site in the period between July 2015 and November 2015. The data obtained during the first month of the measurement were used in the case study, namely the sum total for the first week of the measurement. The data were measured within the

Table 1. Input data for the analysis, number of experimental data points = 24

Hour	Direction	Manual counting	Counter
	in	36	27
1st	out	13	9
	total	49	36
	in	22	23
2nd	out	11	11
	total	33	34
	in	56	45
3rd	out	22	15
	total	78	60
	in	23	15
4th	out	23	16
	total	46	31
	in	14	16
5th	out	20	21
	total	34	37
	in	18	14
6th	out	17	15
	total	35	29
	in	16	10
7th	out	39	24
	total	55	34
	in	16	10
8th	out	29	28
	total	45	38

(a) (b)

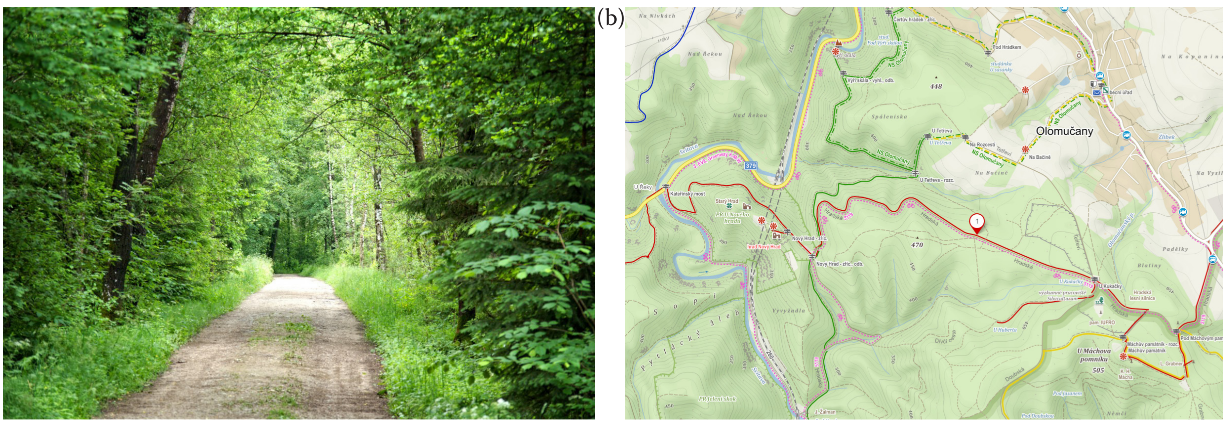

Fig. 1. The Hradská site

time interval of 9 a.m.–5 p.m. Two directions of the visitor flow were monitored – in and out. The input data for the analysis are provided in Table 1.

Table 1 provides two sets of data. The one set comprises the data from monitoring carried out using the automatic pyro sensor, the other set contains the data gained by manual counting performed by the FFWT students.

The following assumption was taken for the purpose of this paper: H_0: The data acquired from the pyroelectric sensor provide relevant information.

The hypothesis will be statistically tested by means of the linear regression analysis. Validation of a new analytical method will be used to clarify the relations between the dependent variable and independent variable. The regression model will be created using the least squares method, which is commonly used in the model creation (Meloun, Militký 2012). The method is described in the chapter Theoretical part.

The ADSTAT 1.25 software was used for the statistical processing of the data.

RESULTS

Firstly, a linear regression model was designed for the validation of the model. The parameters of the model were determined using the least squares 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 expressed as $y = \beta_0 + \beta_1 x$. For this model, the null hypothesis is going to be tested (H_0: $\beta_0 = 0$; $\beta_1 = 0$), i.e. the ideal condition of a line when it is assumed that both the slope and the intercept are zero.

The preliminary data analysis is provided in Table 2. The *R* shows a significant correlation between the variables *y* and *x*.

Table 2. Preliminary data analysis

Variable	Average	SD	*R*	Calculated significance level
y	24.917	12.840	1.000	–
x	32.208	16.395	0.886	0.000

y – dependent variable, *x* – independent variable, SD – standard deviation, *R* – Pearson correlation coefficient

Table 3. Estimates of the regression parameters

Parameter	Estimate	SD	*t*-criterion	H_0	Significance level
b_0	2.5686	2.7867	0.9217	accepted	0.367
b_1	0.6939	0.0774	8.9601	rejected	0.000

b_0 – estimator of the intercept parameters, b_1 – estimator of the slope parameters, SD – standard deviation, H_0 – null hypothesis

Table 4. Basic statistical characteristics of the regression

Characteristic	Value
Multiple correlation coefficient	0.88595
Coefficient of determination	0.78491
Predicted correlation coefficient	0.86869
Mean squared prediction error	38.7680
Akaike information criterion	88.6200

An estimation of parameters was done using the standard least squares method in order to determine the regression parameters of the intercept β_0 and the slope β_1. The analysis was significant at the level of $\alpha = 0.05$. Using 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 Student's distribution $t_{krit} = 2.074$. The evidence for this statement is provided in Table 3.

The basic statistical characteristics of the regression are shown in Table 4.

It follows from Table 3 that according to the *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.

Subsequently, a regression diagnostic is made which comprises so-called regression triplet. This triplet consists of three parts – criticism of the data, of the model, and of the method.

Within the data criticism, the plausibility of the estimate of β_0 and β_1 parameters will be proved. It is necessary to identify influential data points and to exclude strong outliers so as to determine the best-fitted model. The graph of the regression model (Fig. 2) and the graph of classic residuals (Fig. 3) were created using the ADSTAT programme.

The analysis of classic residuals (residuals versus predictions) allows the identification of dubious data points, of a trend, and of heteroscedasticity. Yet the analysis of classic residuals is not very reliable and might not indicate outliers. The graphs 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

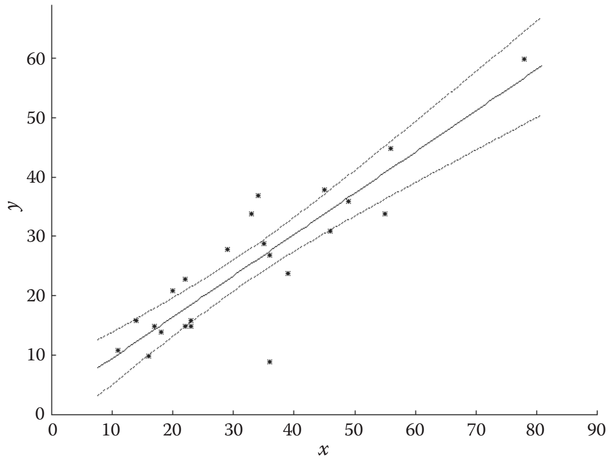

Fig. 2. Graph of the regression model

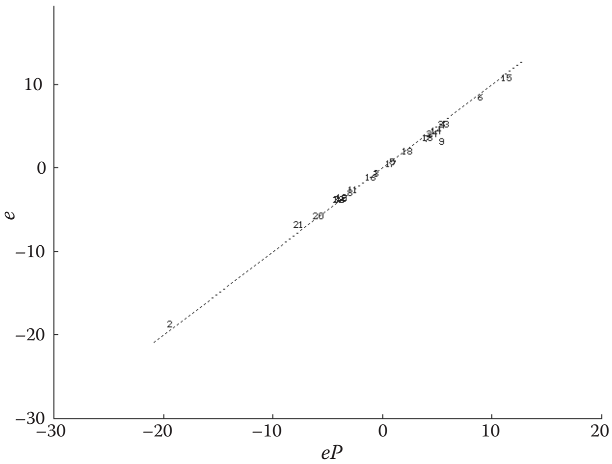

Fig. 4. Graph of the predicted residuals

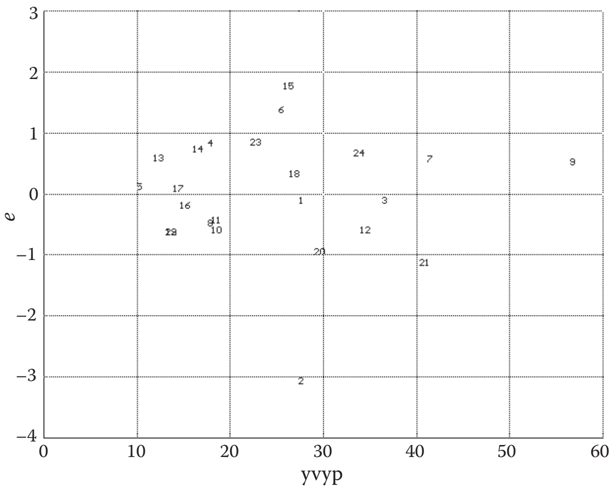

Fig. 3. Analysis of classic residuals

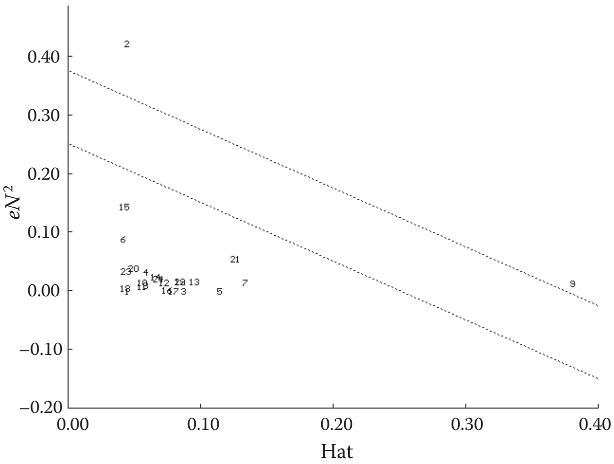

Fig. 5. Pregibon graph

more graphs. In this particular case, the graph of predicted residuals (Fig. 4), Pregibon graph (Fig. 5), Williams graph (Fig. 6), McCulloh-Meeter graph (Fig. 7), and L-R graph (Fig. 8) were used.

The graphical analysis of the influential data points showed that the model contained outliers, the data points of 2 and 9, which had to be eliminated. These points were identified by all five graphs.

The next step is the criticism of the model. Suitability of a model can be assessed based on the course of the model function (Fig. 2). The assumed linear model may be considered suitable since the linear dependence was maintained.

Criticism of the method, or of meeting the basic assumptions of LSM, was carried out using the ADSTAT 1.25 programme. Six presumptions were assessed:

(1) Fisher-Snedecor test for model significance (F):
(*i*) value of the F criterion = 80.284;
(*ii*) table quantile $F(1 - \alpha, m - 1, n - m) = 4.3009$;
(*iii*) conclusion: the designed model is accepted as significant;
(*iv*) calculated significance level = 0.000.

(2) Scott's criterion of multicollinearity (M):
(*i*) value of the M criterion = 0.000;
(*ii*) conclusion: the designed model is correct.

(3) Cook-Weisberg test for heteroscedasticity (Sf):
(*i*) value of the Sf criterion = 121.000;
(*ii*) table quantile, $\chi^2(1 - \alpha, 1) = 3.8415$;
(*iii*) conclusion: the residuals show heteroscedasticity;
(*iv*) calculated significance level = 0.000.

(4) Jarque-Bera test for normality of residuals – $L(e)$:
(*i*) value of the $L(e)$ criterion = 8.5603;
(*ii*) table quantile, $\chi^2(1 - \alpha, 2) = 5.9915$;
(*iii*) conclusion: the normality is not accepted;
(*iv*) calculated significance level = 0.014.

(5) Wald test for autocorrelation (Wa):
(*i*) value of the Wa criterion = 1.0933;
(*ii*) table quantile, $\chi^2(1 - \alpha, 1) = 3.8415$;
(*iii*) conclusion: the residuals have no autocorrelation.

(6) Binomial test of residuals (Dt):
(*i*) value of the Dt criterion = –1.0436;
(*ii*) table quantile, $N(1 - \alpha/2) = 1.6449$;
(*iii*) conclusion: the residuals do not show any trend;
(*iv*) calculated significance level = 0.148.

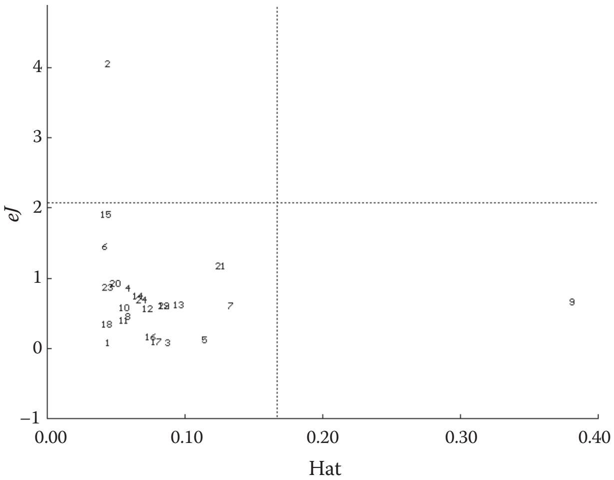

Fig. 6. Williams graph

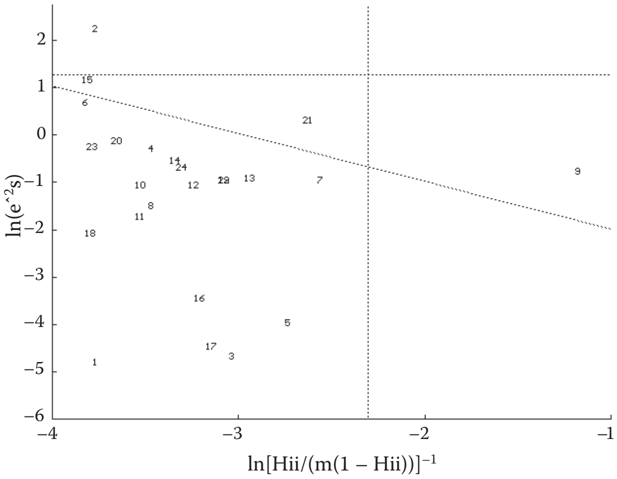

Fig. 7. McCulloh-Meeter graph

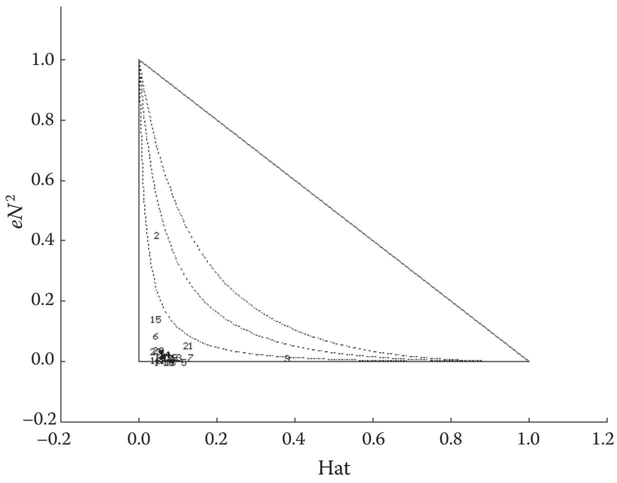

Fig. 8. L_R graph

Table 6. Basic statistical characteristics of the regression

Characteristic	Value
Multiple correlation coefficient	0.89655
Coefficient of determination	0.80379
Predicted correlation coefficient	0.87401
Mean squared prediction error	24.5860
Akaike information criterion	70.3760

The Fisher-Snedecor test proved that the model is significant. The residuals show heteroscedasticity and they are not distributed normally.

Once data points No. 2 and 9 had been eliminated, a refined regression model was created and new parameter estimates of this refined model were fitted. They are shown in Table 5.

Table 6 shows the basic characteristics of the refined model.

The value of the MEP dropped from the value of 38.768 to the value of 24.586; at the same time, the value of the AIC also dropped, from the value of 88.620 to the value of 70.376. The decrease in both values signifies a better quality of the model. Considering the normality of the residuals, the characteristics of the model are also better in this respect, thanks to the elimination of the outliers.

Jarque-Bera test for normality of residuals – $L(e)$:
(*i*) value of the $L(e) = 1.0236$;
(*ii*) table quantile, $\chi^2(1 - \alpha, 2) = 5.9915$;
(*iii*) conclusion: the normality is not accepted;
(*iv*) calculated significance level = 0.599.

Finally, the quality of the model was assessed. The refined model can be formulated as follows (Eq. 4):

$$y = 3.6162(2.4773) + 0.6820(0.0753)x \quad (4)$$

Since there was a decrease in the decisive criteria of MEP and AIC and, at the same time, both the R and the coefficient of determination increased, the specified model can be regarded as of better quality.

The interval parameter estimate of the β_0 intercept is as follows (Eq. 5):

$$\begin{aligned} & b_0 - t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_0)} \le \beta_0 \le b_0 + t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_0)} = \\ & = 3.3162 - 2.074 \times 2.4773 \le \beta_0 \le 3.3162 + 2.074 \times 2.4773 = \quad (5) \\ & = -1.8217 \le \beta_0 \le 8.4541 \end{aligned}$$

Table 5. Estimate of parameters of the refined model

Parameter	Estimate	SD	*t*-criterion	H_0	Significance level
b_0	3.6162	2.4773	1.4323	accepted	0.159
b_1	0.6820	0.0753	9.0517	rejected	0.000

b_0 – estimator of the intercept parameters, b_1 – estimator of the slope parameters, SD – standard deviation, H_0 – null hypothesis

The interval parameter estimate of the β_1 slope is as follows (Eq. 6):

$$b_1 - t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_1)} \leq \beta_1 \leq b_1 + t_{1-\frac{\alpha}{2}}(n-2)\sqrt{D(b_1)} =$$
$$= 0.6820 - 2.074 \times 0.0753 \leq \beta_1 \leq 0.6820 + 2.074 \times 0.0753 = \quad (6)$$
$$= 0.5258 \leq \beta_1 \leq 0.8381$$

DISCUSSION

Determining the best procedures, methods, and techniques of visitor arrival monitoring is essential for assessing the impact of tourism on the high conservation value of natural sites (Wolf et al. 2012). These techniques can also be used to carry out visitor arrival monitoring in Czech forests. Prevailingly, it concerns peri-urban forests (von Janowsky, Becker 2003).

The paper comprises a validation of the analytical method, which assessed whether the pyro sensor provides reliable information and whether it can replace the manual counting of visitor arrivals at a site. The original regression model included 24 data points. Since data points 2 and 9 were outlying, they were eliminated. The outliers were found by the graphical analysis in particular, which was also identified as a suitable method by Meloun and Militký (2012). Subsequently, the refined model with better characteristics was created. The interval estimate for the intercept of the final model contained the 0 value; therefore the intercept can be considered to be nil. The interval estimate for the slope did not contain the value 1; thus, it cannot be considered a unit slope. Based on the results, we can say that the results of visitor arrival monitoring obtained from counting with a pyroelectric counter only slightly differ from the results acquired by the manual counting and that the pyro sensor can provide relevant information. The described method can be employed to assess the data relevance at any site of monitoring. The below-mentioned aspects may affect the relevance of the measurement result of visitor arrival monitoring.

Calibration involves an adjustment of the number of passages recorded by the specific counter in such a way that the estimated number took into consideration errors which originate from the placement of the counter on a profile, from the technical parameters of the counter (for example, which do not allow recording a proper number of persons when several persons are passing aligned), from climatic conditions, and from quantitative errors due to the recording of animals, etc.

Based on my own experience, I can say that the calibration coefficient or the deviation between the measured and actual number of passages is mainly influenced by the following:

(*i*) The road width – wide *x* narrow passage – the wider the passage, the more probable it is that more persons would pass aligned;

(*ii*) The character of visitor arrivals – large groups *x* individuals – this can vary through a year;

(*iii*) The character of terrain – stony road, uphill road, etc. – it can "break" a group of persons and results in more accurate counting;

(*iv*) The counter type – the accuracy of counting is affected by the recording technology (thermal sensor, video detection, etc.).

Other potential causes of deviation in calibration:

(*i*) The recording angle of the sensors placed near the road was limited and they only recorded passages in one direction (from their position towards the road/passage);

(*ii*) In the case of manual counting performed by a specific person, passages of persons who bypassed the electronic counter for any reason (mushroom pickers, herbalists, people walking dogs, etc.) were assessed;

(*iii*) With some posts, there was also a problem with passages of too many persons at a time (such as groups from summer camps or nurseries), where many persons passed aligned.

CONCLUSIONS

Determination of the level to which tourism influences the area is important for managing any area with recreational use. Monitoring of visitor arrivals is currently one of the tools which help to determine the quality and appropriate management of the given site. The methods of visitor arrival monitoring are fundamental for assessing the impacts of tourism on protected as well as other areas. There are many methods of visitor arrival monitoring.

This paper concentrates on visitor arrival monitoring carried out by means of automatic visitor counting using a field counting device, specifically a pyroelectric sensor (pyro sensor).

The aim of the article was to determine whether a pyroelectric sensor provides relevant information with the help of the data acquired from the selected site by means of a regression analysis. Subsequently, validation of the analytical method was performed. Two sets of data were compared for the same site and for the sum total of the first week of visitor arrival monitoring in July 2015. The one set contained the data from automatic monitoring by the pyro sensor, the other comprised the data acquired by means of manual counting carried out by the students of the Faculty of Forestry and Wood Technology of Mendel University in Brno. Both directions of the visitor flow, in and out, were monitored. The statistical data processing was performed using the ADSTAT 1.25 software. The original regression model comprised 24 data points. Data points 2 and 9 were eliminated as outliers; they were found out by the graphical analyses in particular. The refined model with better characteristics was created. The results of the regression analysis showed that the results of the visitor arrival monitoring carried out by a pyro sensor differ from the results of manual counting just slightly. The hypothesis set at the beginning of research is not rejected. The described method can also be used for the assessment of the relevance of data from other monitored sites.

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. Hradec Králové, University of Hradec Králové: 44.

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.

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.

Bláha P. (2010): Výsledky monitorování a jejich využití v praxi – Liberecký kraj. Ochrana přírody 2010 – 2.8.2010, special issue. Available at http://www.casopis.ochranaprirody.cz/zvlastni-cislo/vysledky-monitorovani-a-jejich-vyuziti-v-praxi-liberecky-kraj/ (accessed July 18, 2017).

Cessford G., Muhar A. (2003): Monitoring options for visitor numbers in national parks and natural areas. Journal for Nature Conservation, 11: 240–250.

Cole D.N. (1989): Wilderness Campsite Monitoring Methods: A Sourcebook (General Technical Report, INT-259). Ogden, USDA Forest Service Intermountain Research Station: 25.

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: 507–520.

Fagiolo G., Moneta A., Windrum P. (2007). A critical guide to empirical validation of agent-based models in economics: Methodologies, procedures, and open problems. Computational Economics, 30: 195–226.

Hall D., Mitchel M., Roberts L. (2005): Tourism and the countryside: Dynamic relationship. In: Hall D., Roberts L., Mitchell M. (eds): New Directions in Rural Tourism. Aldershort, Ashgate Publishing, Ltd.: 3–18.

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: 477–508.

Kala L., Salov T. (2010): Výsledky monitorování a jejich využití v praxi – České Švýcarsko. Ochrana přírody 2010 – 2.8.2010, special issue. Available at http://www.casopis.ochranaprirody.cz/zvlastni-cislo/vysledky-monitorovani-a-jejich-vyuziti-v-praxi-ceske-svycarsko/ (accessed July 20, 2017).

Kettler D. (1970): Die Erholungsnachfrage in stadtnahen Wäldern: dargelegt am Beispiel der Räume Stuttgart, Karlsruhe, Heidelberg und Mannheim (mit Ergänzungen bei Freiburg, Baden-Baden und im Schönbuch): ein Beitrag zum Europäischen Naturschutzjahr. Freiburg im Breisgau, Baden-Württembergischen Forstlichen Versuchs- und Forschungsanstalt: 170.

Kos J. (2010): Výsledky monitorování a jejich využití v praxi – Národní park Podyjí. Ochrana přírody 2010 – 2.8.2010, special issue. Available at http://www.casopis.ochranaprirody.cz/zvlastni-cislo/vysledky-monitorovani-a-jejich-vyuziti-v-praxi-narodni-park-podyji/ (accessed July 22, 2010).

Lama W.B., Sattar N. (2002): Mountain tourism and the conservation of biological and cultural diversity. In: Global Mountain Summit, Bishkek, Apr 23–28, 2002: 1–32.

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): Proceedings of the Monitoring and Management of Visitor Flows in Recreational and Protected Areas Conference, Vienna, Jan 30–Feb 2, 2002: 306–313.

Meloun M., Militký J. (2012): Kompendium statistického zpracování dat. Prague, Karolinum: 985.

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

Miller A.B., Leung Y.F., Kays R. (2017): Coupling visitor and wildlife monitoring in protected areas using camera traps. Journal of Outdoor Recreation and Tourism, 17: 44–53.

Muhar A., Arnberger A., Brandeburg C. (2005): Monitoring of visitor flows and visitor needs as a basic for protected area management. In: Bauch K. (ed.): Proceedings of the 3rd Symposion of the Hohe Tauern National Park for Research in Protected Areas, Kaprun, Sept 15–17, 2005: 153–157.

Riley C.M., Rosanske T.W. (eds) (1996): Development and Validation of Analytical Methods. Oxford, Elsevier: 352.

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: Sharpley R., Telfer D.J. (eds): Tourism and Development. Concepts and Issues. Clevedon, Channel View Publications: 35–80.

Volk H. (1992): Neue Entwicklungen bei der Walderholung in Südwestdeutschland. Forstwissenschaftliches Centralblatt, 111: 282–292.

von Janowsky D., Becker G. (2003): Characteristics and needs of different user groups in the urban forest of Stuttgart. Journal for Nature Conservation, 11: 251–259.

Weaver D.B., Lawton L.J. (2017): A new visitation paradigm for protected areas. Tourism Management, 60: 140–146.

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: 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.): Proceedings of the Public Recreation and Landscape Protection – Hand in Hand Conference, Křtiny, May 2–4, 2012: 177–184.

Received for publication March 15, 2018
Accepted after corrections July 25, 2018