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THE USE OF CAMERA TRAPS FOR IDENTIFYING VARIOUS TYPES OF FOREST RECREATIONAL ACTIVITIES ON THE EXAMPLE OF WDECKI LANDSCAPE PARK

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ABSTRACT

Motives: Unlike nature monitoring, recreational activities in forests are not monitored regularly over wide areas. Therefore, research studies involving various methodologies are needed to generate valuable data for forest management.
Aim: The aim of the present study was to identify different types of forest recreational activities in Wdecki Landscape Park based on data recorded by seven camera traps between 12 December 2019 and 12 December 2020.
Results: The collected data revealed that walking, biking, and mushroom picking were the most popular recreational activities. Most activities were undertaken by single visitors or groups of two visitors between 10:00 a.m. and 4:00 p.m., mostly on weekends and in the autumn.

Keywords: recreation, tourism, forest, forest visits, visitor monitoring

INTRODUCTION

The perception of the role of forests has changed over the centuries. Until the beginning of the 20th century, the forest was perceived mainly as a place for timber production (Paschalis-Jakubowicz, 2005). Nowadays, model of multifunctional and sustainable forest management provides opportunity for forest areas to fulfil three different functions in the same place and time: production, protection and social. As numerous scientific studies show, social function is very important in society's opinion (Gołos, 2013). That function covers a wide range of issues, including those related to recreation and tourism (Roovers et al.,

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2002). The explanation for the great importance of this function can be seen in a generally increasing interest in contact with nature. The natural environment, mainly forest areas, has a positive effect on well-being and can be a key factor in improving and restoring mental balance disturbed by fatigue (Furuyashiki et al., 2019). As indicated by van den Berg et al. (2003) and Staats et al. (2003) natural environments more than urban environments allow regeneration. Moreover, scientific studies developed over the years show that contact with nature reduces stress level (theory of psychophysical stress reduction) (Ulrich, 1981; Ulrich et al., 1991; Hartig et al., 2003), distances from business activities and family matters (attention regeneration theory) (Kaplan, 1995) or has a positive effect on improving concentration (Tomalak, 2006). According to Gołos (2003), a forest is a place where the inhabitants, especially of urban areas, can fulfill one of their basic needs i.e. contact with nature. This need was also noticeable during the COVID-19 pandemic (Derks et al., 2020; Ugolini et al., 2020). Recreation in forest areas can take various forms of active and passive recreation. Among the most popular forms of activities walking, running, nordic walking, biking or gathering forest fruits should be listed (Ciesielski & Stereńczak, 2018). The demand for recreational activities is also changing. In addition to the above-mentioned "traditional" forms of activity, new forms of recreation such as bushcraft or geocaching are becoming more and more popular nowadays (Samołyk, 2013; Ciesielski & Stereńczak, 2018). The State Forests, which manage more than 77% of the forests in Poland, undertake numerous activities to adapt the recreational infrastructure to the needs of different user groups. The development of the infrastructure aims, among other things, to protect natural resources from overexploitation by recreation and tourism (Hadwen et al., 2008; Lyon et al., 2011). To take appropriate action, State Forests need tools and data to make decisions that minimize the negative impacts of recreation on forest ecosystems. The data and tool are especially important for agencies that manage forests in agglomeration and near major cities as well as forests in areas of high natural and landscape values.

LITERATURE REVIEW

In order to provide the agencies responsible for forest management with information on the time and place of activities in forest, research has been conducted for many years in the area of recreational use of forest. The most popular method used in the research have been the questionnaires taken on samples of different sizes and characterized by different socio-demographic profiles of the sample, and with different scale of study (local, regional, country) (Pietilä et al., 2015; Gundersen et al., 2017). Data were collected on-site using variety of techniques (including written surveys, direct questionnaire interviews [PAPI – Paper & Pen Personal Interview], personal interviews supported by computer techniques [CAPI – Computer Assisted Personal Interview]), as well as by telephone (CATI – Computer Assisted Telephone Interview) and via the Internet (CAWI – Computer Assisted Web Interviewing) (Cessford & Muhar, 2003). With the help of questionnaire surveys, a diagnosis of the temporal and spatial distribution of activities in forest areas was made. Based on the answers of the respondents, it can be stated that the recreational use of forests is various and depends on the time of a day, a day of the week or season, as well as the form of the activity (Roovers et al., 2002; Arnberger, 2006; Janeczko & Woźnicka, 2009). Surveys were also used to identify: the need for recreation in the forest (Dudek, 2016a), factors influencing the attractiveness of forest areas, factors disturbing recreation (Gundersen & Frivold, 2008; Nielsen et al., 2012; Gołos, 2013), and preferences regarding recreation infrastructure and forest management (Verlič et al., 2015; Dudek, 2016b). In some studies (Gołos, 2013), respondents indicated which areas they preferred to visit based on a direct questionnaire, but it is not certain that this is true. Kienast et al. (2012) used a grid of 1 km x 1 km base squares to indicate the places that respondents visit for recreational purposes. Respondents indicated areas where they were spending time for recreational purposes on weekdays and weekends. In the work of Meijels et al. (2014), in addition to answering the questionnaire, respondents were asked to record their

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movement route through the forest complex using a GPS device. The information recorded by GPS made it possible to indicate the spatial distribution of the subjects, the distances they travelled, and the locations and times of stops (Taczanowska et al., 2008). A few studies also used pyroelectric sensors (Taczanowska et al., 2017; 2018) and video cameras (Arnberger, 2006) on forest areas. Pyroelectric sensors have been used much more frequently in the analysis of tourist traffic in national parks in Poland (Spychała & Graja-Zwolińska, 2014), e.g., in Stołowe Mountains (Rogowski, 2017; 2020), Bieszczady (Prędki, 2012), and Tatra (Hibner, 2014). As Willberg et al. (2021) point out, more accurate information about the location and timing of activity can be obtained with data from GPS recipients than with data from surveys. According to Lupp et al. (2021), an alternative source of quantitative and qualitative data on recreation in forests can be data from camera traps. They provide continuous data 24/7 and, most importantly, do not require the availability of large numbers of people to operate them and are easy to use. So far, camera traps have been used mostly for research related to wildlife monitoring, but according to Lupp et al. (2021), they can also be used as a data source for describing recreation. Data collected by Arnberger et al. (2005) showed that the difference between the number of people detected by counting in the field and the data from camera traps was 15%.

Monitoring of recreational use of the forest is rare, and most forest management agencies in Europe do not conduct this type of monitoring. Therefore, any research in this area, even for the smallest forest complexes, can provide the basis for effective management of these areas (Cessfor & Muhar, 2003). Taking above into consideration, the aim of the present study was to determine the recreational use of forest areas in the Wdecki Landscape Park area based on data collected by seven photo-traps. The study attempted to answer the following research questions:

1. At what time of the day, week and year do recreational activities take place in forest areas?
2. How often and when do different user groups participate in recreation activities?
3. Are forestry activities carried out during the periods of lower recreational use?

MATERIALS AND METHODS

The research area was located in one of the largest forest complexes of Poland – Bory Tucholskie. More precisely, in the southwestern region of the Wdecki Landscape Park. The park was established by Regulation of the Voivode of Bydgoszcz on February 16, 1993 (Regulation, 1993). The park with its buffer zone covers 23786.39 ha, including 4609.15 ha buffer zone. According to the land survey, 69.6% of the park is covered by forests, 27.2% is agricultural and urbanized land, and 3.2% is water. The forest areas of the park are located in the following forest districts: Osie, Trzebciny, Dąbrowa, and Zamrzenica. There are 3 nature reserves (Dury, Brzęki and Miedzno) near the camera traps, where there are many rare species of plants and animals, which are protected under the active protection of endangered species program. Here the influence of two extremely different climates is noticeable: the continental Eastern Europe and, to a lesser extent, the maritime climate of Western Europe. The number of frosty days per year is 100–110. Precipitation averages 450–550 mm per year, with snow cover lasting about 50–70 days, longest in the forest areas. The growing season lasts about 210–220 days, from the end of March to the first days of November. During the growing season, precipitation is about 280–340 mm (Boiński, 1999).

The analysis of tourist pressure in the Wdecki Landscape Park was based on the material recorded by camera traps. Camera traps have been installed in a forest area from approx. 4 km (camera traps – B, C) to 9 km (camera traps A) from the nearest buildings in Osie (approx. 3 thousand residents). These devices were installed in the stand on the tree stem at the intersection of forest paths. The cameras were set to record 30 seconds movies with an interval of 1 seconds. Trigger speed of the cameras was 0.2–0.7s (recommended value from the literature, including Weingarth et al. (2013). Cameras operated around the clock. The cameras collected data from 12.12.2019 to 12.12.2020. After downloading the

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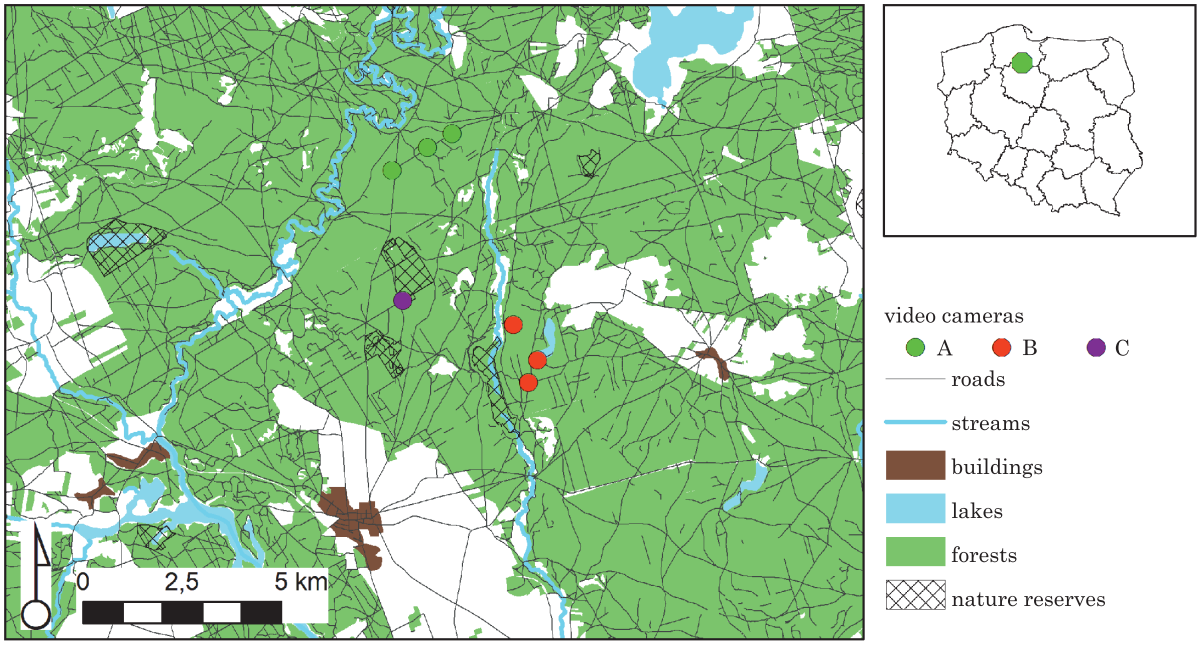

Fig. 1. Location of the study area
Source: own preparation.

data from the cameras about the recorded activities, they were divided into two groups: pedestrians and vehicles. This was then done with Powershell to avoid errors in manually entering dates and times. Finally, only information about pedestrians was used for the analyzes. Then, each record (one activity) in the database was described in detail, including: number of people (single visitors, group of people (2 and more without classification into family, pair etc.), behaviour (forest work, walking, biking, nordic walking, mushroom picking, jogging, hunting, other) and the date and time of registration of the activity. The information collected in the database was analyzed according to the selected periods: hours, days of the week, and months, broken down by registered pedestrian behaviour. Information from camera traps was also analyzed for the selected subareas (A, B, C) (Fig. 1). Statistical analyzes of the differences in the number of registered activities were also performed using the Kruskal-Wallis test. All calculations were performed with the STATISTICA 13.1 package (Dell Inc., Tulsa, OK, USA).

RESULTS

A general overview of recreational activities in the park

During the analysis period, the camera traps registered a total of 1358 people. The most common activity was walking (29%), followed by biking (27%) and mushroom picking (20%) (Chart 1). In the distinguished sub-areas A and C, walking was also the most popular (26.4% and 37.7%, respectively). In area B, 35.6% of activities were related to forest work and 19.5% were walks.

From the detailed data analysis, it was also possible to identify whether the activity was performed by single visitors or in groups (two or more people) (Chart 2). Considering all activities, 50.8% of them were performed by single visitors and 33.1% in groups of two. Mushroom picking and biking were also activities that were mainly done by single visitors (56% and 64%) and in groups of two (22% and 26%). Thirty-nine percent of the registered persons

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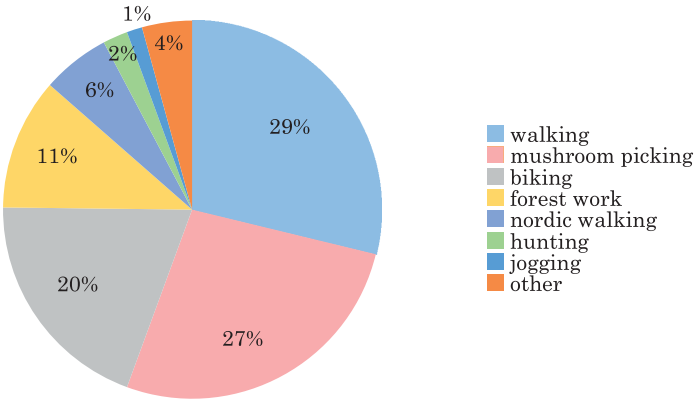

Chart 1. Percentage of people undertaking certain recreational activities
Source: own preparation.

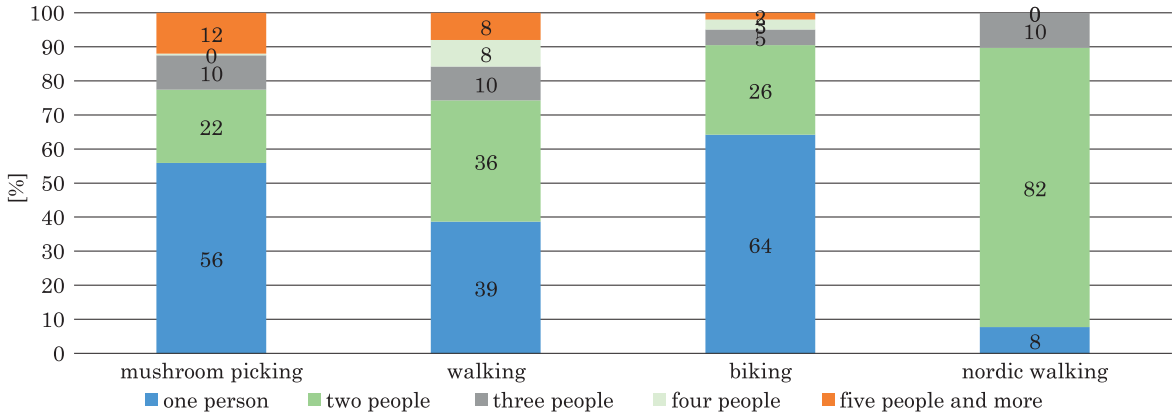

Chart 2. Percentage of people undertaking the selected activity individually and in groups of 2 or more
Source: own preparation.

undertook hiking alone and 36% in groups of two. For nordic walking, only 8% of the people opted for a single activity and 82% for a group of two. Groups of 5 people were observed picking mushrooms (12%), hiking (8%) and biking (2%).

Daily visitation dynamics (visitation per time of day)

The temporal distribution of activities shows that activities were carried out between 4:00 a.m.–9:00 p.m. In the morning hours (4:00 a.m. – 10:00 a.m.), 7.3% of all activities were recorded in the entire study area. 83.6% of activities took place in the early afternoon hours, lunch time and afternoon (10:00 a.m. – 4:00 p.m.). The remaining 8.1% of activities occurred after 4:00 p.m. The peak of activity was reached at 12:00 a.m. (17.9%). In areas A and C, the percentage distribution of activity was similar to the whole area. It should be noted that the percentage of activity in area A at 12:00 a.m. was 22.2%, which is 4.3 percentage points more than the result for the whole area. In the last area (B) the highest percentage of activity was recorded at 3:00 p.m., it was 20.7% (Chart 3). Particular activities were performed at the following hourly intervals: running – 12:00 a.m.–4:00 p.m., nordic walking – 11:00 a.m. – 5:00 p.m., walks – 8:00 a.m. – 8:00 p.m., mushroom picking – 5:00 a.m. – 6:00 p.m., hunting – 6:00 a.m. – 8:00 a.m. and 5:00 p.m. – 9:00 p.m.

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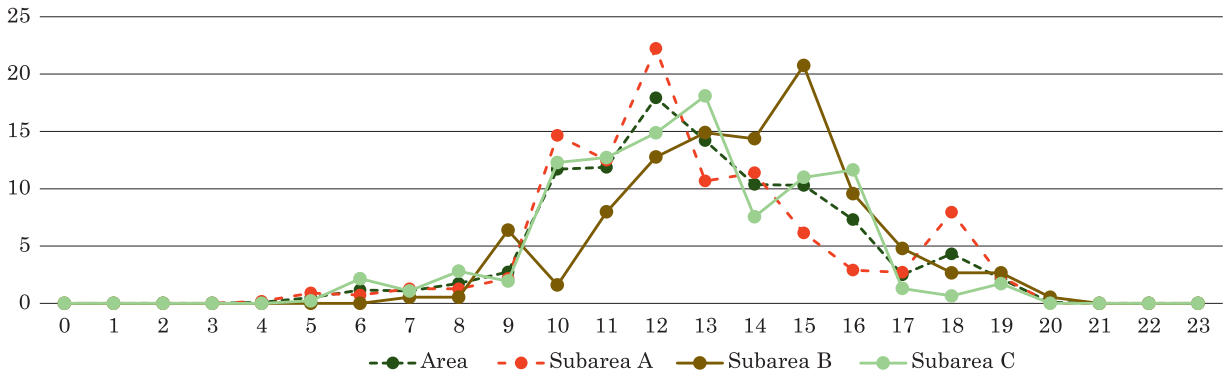

Chart 3. Percentage of people registered by camera traps in particular hours
Source: own preparation.

Weekly visitation dynamics (visitation per day of week)

From Monday to Thursday, the percentage of activities initiated was similar, ranging from 5.3% on Thursday to 9.6% on Tuesday. About 15.9% of all activities during the week were recorded on Friday. Significantly more activities (p-value 0,000) were undertaken on weekends (Saturday–Sunday), when 53.2% of activities occurred (Chart 4). There were no differences between individual areas or between areas and the entire study area. The individual activities were also carried out mainly on weekends. It is only worth mentioning that: 4.6% of forest work took place on weekends, i.e. during the highest recreational activity and 75.9% of all data related to nordic walking were reported on weekdays.

The percentage distribution of activities on a weekly basis was different in the different seasons. In winter, 43% of all activities took place on weekends; in summer, this percentage was similar and amounted to 40%. In spring it was higher and reached 58%, and in autumn 63% of activities took place on weekends (Chart 5).

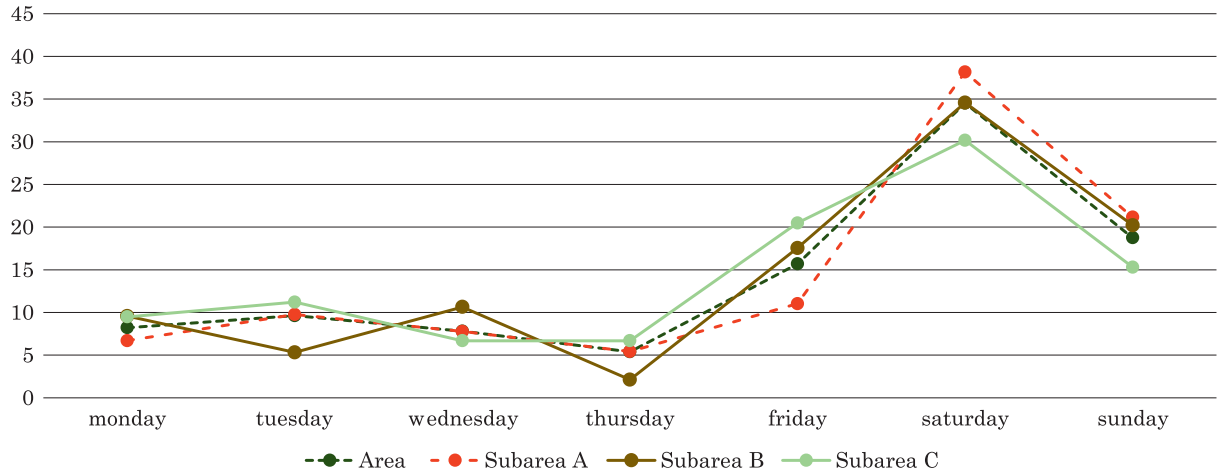

Chart 4. Percentage of people registered by camera traps on individual days of the week
Source: own preparation.

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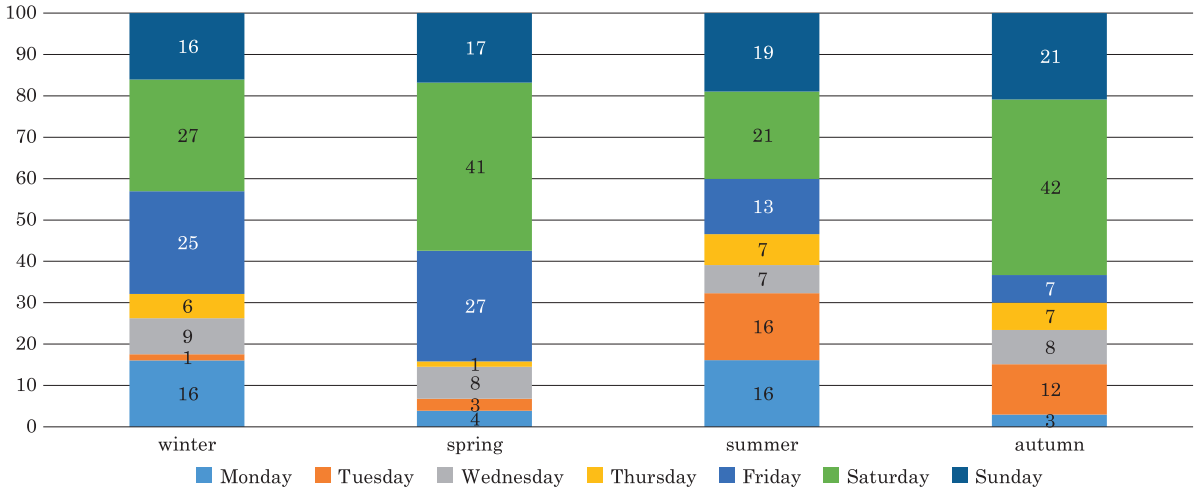

Chart 5. Percentage of people recorded by camera traps on individual days of the week and seasons of the year
Source: own preparation.

Monthly visitation dynamics

The most activity was observed in autumn (36.2%), followed by summer (26.7%), spring (25.7%) and winter (11.3%). The most popular month was October with 29.3% of all activity. Two peaks of activity in June and in September and October were recorded. There were no differences in the number of activities in each month in the distinguished areas A, B, C, except pairs: July–June, July–October, and January–June (Chart 6). There are significant differences in the number of visitors to forest areas in the following pairs: winter–spring (p-value 0,002), winter–autumn (p-value 0,000), summer–spring (p-value 0,002) and summer–autumn (p-value 0,003). Area C in winter was significantly more often used than area A, and in spring area B than area A. Individual activities varied on a monthly basis, i.e:

1. 96.6% of hunting place in the period September-November;

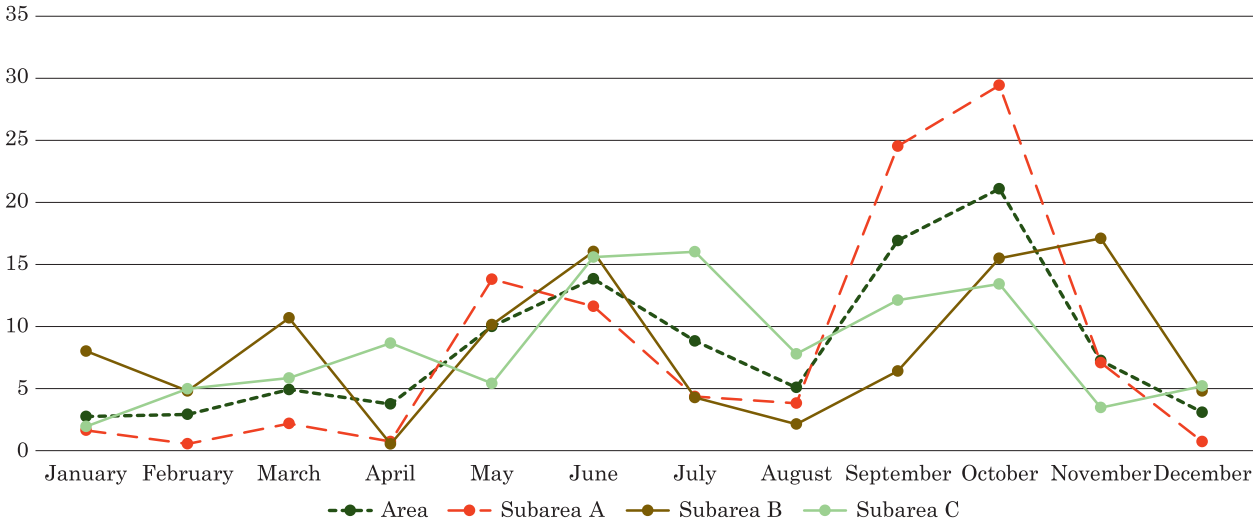

Chart 6. Percentage of people registered by camera traps in months
Source: own preparation.

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2. 75.2% of forest work were carried out in the winter period (December-March), and only 1.3% in the holiday period (June-August);
3. 81.9% of mushroom picking were observed in September and October, and all activities took place from June to November;
4. 80.1% of biking took place from May to September, with the highest percentage in June (21.8%);
5. 39.7% of walking occurred in May and June, and this activity continued throughout the year;
6. 30.4% of all observed nordic walking activity took place in May.

DISCUSSION

The use of activity monitoring in natural areas results from the need to answer five basic questions: where does recreation occur (spatial distribution), when (temporal distribution), who stays in the area and why, and what activity are undertaken. Different monitoring methods allow answering those questions at different levels (Willberg et al., 2021). The indirect monitoring method used in this article, i.e., camera traps, provided answers to 3 of those questions, namely, Where? Who? What? The data from the cameras allowed us to determine the intensity of recreational use (the number of people and the number of people in the group), spatial distribution, and behaviour (activity). In the studies presented, the most common activities undertaken were walking, mushroom picking, and biking. The results obtained in the study are consistent with the results of previous studies conducted in different areas and with different methods (Eriksson et al., 2012; Gołos, 2013). According to Gołos (2013), for 15% of the respondents, the main activity in the forest was walking with the family, while 27% walked with the dog. Roovers et al. (2002) showed that there are differences in the type of activity undertaken by different age groups. The decision on the type of activity is also influenced by the day of the week and the availability of free time (Skłodowski et al., 2013). The authors pointed out that active leisure time dominates on weekdays, while family walks are most popular on weekends and during vacations. It should be emphasized that the activities related to forest work were carried out during the period of lower recreational activity (winter period). Hunting was also carried out in the early morning and evening hours, mainly due to the conditions and activity of the animals. However, considering the potential conflicts with people resting in the forest and hunters, such separation of activity periods is advisable. The issue of conflict between different user groups is prevalent in the literature and was highlighted by Seeland et al. (2002). The authors emphasized that the risk of conflict with hunters is high, which also results from the lack of acceptance for this type of activity. The same applies to timber harvesting. When it comes to safety during forest work, access to the area where the work is carried out is prohibited. Considering the need for recreation in the forests, it is also advisable to schedule forestry work during the period of lower recreational intensity.

The schedule of activities presented in the study showed that the vast majority of them took place between 10:00 a.m. to 4:00 p.m. As in Arnberger (2006) or Ciesielski & Stereńczak (2020), who conducted their research using video cameras and social network data, respectively, the increase in activity took place between 8:00 a.m. and 9:00 a.m., and the highest percentage of people stayed in the forests between 12:00 a.m. – 5:00 p.m. The percentage of activity was also higher in the evening (6:00 p.m. – 8:00 p.m.) than in the morning (6:00 a.m. – 9:00 a.m.), what confirms the results of Janowsky & Becker (2003) in the Stuttgart forest area. In the presented studies, most activities were undertaken on weekends, which is directly related to the availability of free time (Skłodowski et al., 2013; Ciesielski & Stereńczak, 2021). The weekend has also been reported in work using other research methods as the time of greatest activity during the week: video cameras in suburban and urban forests (Arnberger, 2006); pyroelectric sensors in metropolitan areas (Taczanowska et al., 2018); volunteered geographic information data from the Flickr portal for state forests (Ciesielski & Stereńczak, 2020; 2021); survey studies on various research for

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forests in different regions of Poland (Skłodowski et al., 2013; Gołos, 2013).

The data obtained from the camera traps show that recreation in the study area occurs with varying intensity throughout the year, which could be due to the tourist attractions of the area. Variability of recreational use of the forest is also related to weather (Gołos, 2018), psychological and aesthetic aspects (Gołos, 2018), availability of mushrooms and forest fruits (Graja-Zwolińska & Spychała, 2011), among others. Contrary to most studies, where the peak of recreational activity was in summer (Skłodowski et al. 2013; Gołos, 2013), in the presented area the highest percentage of people was registered in autumn and then in spring. This could be due to the characteristic of the area, or influence of the COVID-19 restrictions, which largely regulated the activity of the society in 2020 (Ciesielski et al., 2022).

In terms of the practical application of this type of data collection, the location of the camera traps is important. As indicated by Lupp et al. (2021), the cameras should be installed at a height of 4 m above the ground and aimed at the trail at a distance of 20 m. It is recommended that the path width does not exceed 3 m. According to Weingarth et al. (2013), the difference between data from camera traps and manual measurement can be up to 15%. The location of monitoring sites should take into account the actual situation in a given area. An example of a properly constructed monitoring system, but based on pyroelectric sensors, is the system described by Rogowski (2018) for monitoring tourist traffic in Stołowe Mountains. The author presented the preparation phases (inside and in the field), the current functioning of the system, and the review and modification of the system. The collection of data when using camera traps is also subject to the legal provisions of the General Data Protection Regulation, the so-called GDPR. In this case, the provisions of the GDPR protect car license plates and the faces of passers-by, which must be properly covered. You should also remember to properly secure the collected data, for example, through encryption (the Advanced Encryption Standard system), so that if the equipment is stolen, the thief will not be able to recover the data. Processing data from camera traps is time consuming, especially when we manually review each records and create a database. In this study, we mainly aimed to quantify visitors and the type of activity was additional information. According to Lupp et al. (2021), based on photographs, it is also possible to determine gender (male, female), grouping (individual, two people, family, group, guided group), age classification (baby, toddler, 7–10 years, 10–14 years, youth over 14 years, adult), walking direction (i.e., in-out), and level of attention (i.e., on the trail, in the forest, using a mobile device). The accuracy of determining these characteristics varies, ranging from 50% for sex to 75% for age to 95% for activity. The accuracy of the determination of the characteristics depends, among other things, on the blurriness of the photos.

CONCLUSIONS

Monitoring recreational use of forest areas is not a common topic and there is no single comprehensive monitoring method. It is worth using a variety of methods to obtain data on recreation in forests. The use of data from camera traps collected while monitoring animal activity provided valuable information about recreation in Wdecki Landscape Park. The undisputed advantages of this method include the cost of purchasing and installing the equipment and ensuring 24/7 monitoring. The data provided not only quantitative information (number of people), but also qualitative information representing the type of activity performed. The use of data from camera traps made it possible to indicate the intensity of recreational traffic on a daily basis, days of the week, months, and seasons. The data show that the study area was most frequently visited by recreationists between 10 a.m. and 4 p.m., on weekends, and in the autumn. The most popular activities were also identified, which were: (29%), biking (27%) and mushroom picking (20%). It should be emphasized that the problem of recreation in the forest has a legal basis. Among others, the Forest Management Instruction (Instruction, 2011) indicates that the mandatory

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element of the Forest Management Plan is the chapter on recreation, which is entitled "Identification of needs in the field of technical infrastructure, including tourism and recreation". Therefore, the information obtained from the camera traps can support the decision-making process at the forest district level regarding the development of recreation infrastructure or the adaptation of the forest work plan to the period of lower recreation use.

The limitations of the research conducted include:

1. The monitoring period covered one year, so it was not possible to compare results in different years. This is important because the results could be influenced by factors such as weather, events in the study area, and, most importantly, restrictions introduced by the government during the pandemic COVID-19 (Rice & Pan, 2021; Ciesielski et al., 2022).
2. Data were collected in points with a limited number of camera traps. Thus, the data provide information on the recreational use of individual sections of the roads and paths. For future studies, it is necessary to consider increasing the number of camera traps and distributing them in a representative manners within the research area. To obtain comprehensive information on recreational use in the studied area, it is necessary to combine the camera trap data with other monitoring methods.
3. A significant limitation of the monitoring method with the use of camera traps is the great amount of data and the associated time-consuming analysis of the photos and video files (Lupp et al., 2016). In the future, data processing could be accelerated by the use of automated methods for analysing image content.

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REFERENCES

Arnberger, A. (2006). Recreation use of urban forests: As inter-area comparison. *Urban Forestry & Urban Greening*, *4*, 135–144. https://doi.org/10.1016/j.ufug.2006.01.004.

Arnberger, A., Haider, W., & Brandenburg, C. (2005). Evaluating visitor-monitoring techniques: A comparison of counting and video observation data. *Environmental Management*, *35*, 1–12. https://doi.org/10.1007/s00267-004-8201-6.

van den Berg, A. E., Koole, S.L., & Wulp, N.Y. (2003). Environmental preference and restoration: (How) are they related? *Journal of Environmental Psychology*, *23*, 135–146. https://doi.org/10.1016/S0272-4944(02)00111-1.

Boiński, M. (1999). *Szata leśna Wdeckiego Parku Krajobrazowego [Forest cover of the Wdecki Landscape Park]*. Toruń: Wydawnictwo Uniwersytetu Mikołaja Kopernika.

Cessford, G., & Muhar, A. (2003). Monitoring options for visitor numbers in national parks and natural areas. *Journal for Nature Conservation*, *11*(4), 240–250. https://doi.org/10.1078/1617-1381-00055.

Ciesielski, M., & Stereńczak, K. (2018). What do we expect from forests? The European view of public demands. *Journal of Environmental Management*, *209*, 139–151. https://doi.org/10.1016/j.jenvman.2017.12.032.

Ciesielski, M., & Stereńczak, K. (2020). Volunteered Geographic Information data as a source of information on the use of forests in the Warsaw agglomeration. *Sylwan*, *164*(8), 695–704. https://doi.org/10.26202/sylwan.2020043.

Ciesielski, M., & Stereńczak, K. (2021). Using Flickr data and selected environmental characteristics to analyse the temporal and spatial distribution of activities in forest areas. *Forest Policy and Economics*, *129*, 102509. https://doi.org/10.1016/j.forpol.2021.102509.

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Ciesielski, M., Tkaczyk, M., Hycza, T., & Taczanowska, K. (2022). Was it really different? COVID-19-pandemic period in long-term recreation monitoring – A case study from Polish forests. *Journal of Outdoor Recreation and Tourism*, 100495. https://doi.org/10.1016/j.jort.2022.100495.

Derks, J., Giessen, L., & Winkel, G. (2020). COVID-19-induced visitor boom reveals the importance of forests as critical infrastructure. *Forest Policy and Economics*, *118*, 102253. https://doi.org/10.1016/j.forpol.2020.102253.

Dudek, T. (2016a). Potencjał rekreacyjny lasów podmiejskich Rzeszowa wobec zapotrzebowania na wypoczynek w lasach wśród mieszkańców województwa podkarpackiego [Recreational potential of Rzeszów suburban forests versus the demand for spending leisure time in forests among the residents of the Podkarpackie Province]. *Sylwan*, *160*(2), 169–176. https://doi.org/10.26202/sylwan.2015100.

Dudek, T. (2016b). Needs of the local population related to development of forests for recreational purposes: example of south-eastern Poland. *Journal of Forest Science*, *62*, 35–40. https://doi.org/10.17221/99/2015-JFS.

Eriksson, L., Nordlund, A., Olsson, O., & Westin, K. (2012). Recreation in different forest settings: a scene preference study. *Forests*, *3*, 923e943. https://doi.org/10.3390/f3040923.

Furuyashiki, A., Tabuchi, K., Norikoshi, K., Kobayashi, T., & Oriyama, S. (2019). A comparative study of the physiological and psychological effects of forest bathing (Shinrin-yoku) on working age people with and without depressive tendencies. *Environmental Health and Preventive Medicine*, *24*(1), 46. https://doi.org/10.1186/s12199-019-0800-1.

Gołos, P. (2013). Selected aspects of the forest recreational function in view of its users. *Forest Research Papers*, *74*(3), 257–272. https://doi.org/10.2478/frp-2013-0025.

Gołos, P. (2018). *Społeczne i ekonomiczne aspekty pozaprodukcyjnych funkcji lasu i gospodarki leśnej – wyniki badań opinii społecznej* [Summary – Social and Economic Aspects of Non-Productive Functions of Forests and Forest Management – Results of Public Opinion Survey]. Prace Instytutu Badawczego Leśnictwa, Sękocin Stary. Retrieved from: https://www.researchgate.net/publication/328873974_Summary_-_Social_and_Economic_Aspects_of_Non-Productive_Functions_of_Forests_and_Forest_Management_-_Results_of_Public_Opinion_Survey (27.09.2022).

Graja-Zwolińska, S., & Spychała, A. (2011). Sylwaturystyka w świadomości potencjalnych kreatorów ruchu turystycznego [Forest tourism in the consciousness of potential tourism traffic Creators]. *Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej* [*CEPL Studies and Materials in Rogów*], *13*(3), 227–231. Retrieved from: http://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-5792d341-cf34-49b9-8558-0df88c11810f (27.09.2022).

Gundersen, V., Stange, E., Kaltenborn, B., & Vistad O. (2017). Public visual preferences for dead wood in natural boreal forests: The effects of added information. *Landscape and Urban Planning*, *158*, 12–24. https://doi.org/10.1016/j.landurbplan.2016.09.020.

Gundersen, V., & Frivold, L. (2008). Public preferences for forest structures: A review of quantitative surveys from Finland, Norway and Sweden. *Urban Forestry & Urban Greening*, *7*, 241–258. https://doi.org/10.1016/j.ufug.2008.05.001.

Hadwen, W.L., Hill, W., & Pickering, C. (2008). Linking visitor impact research to visitor impact monitoring in protected areas. *Journal of Ecotourism*, *7*, 87–93. https://doi.org/10.2167/joe193.0.

Hartig, T., Evans, G.W., Jamner, L.D., Davis, D.S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*, *23*, 109–123. https://doi.org/10.1016/S0272-4944(02)00109-3.

Hibner, J. (2014). Monitoring ruchu turystycznego w rejonie Kasprowego Wierchu – metody i problemy badawcze [Monitoring of tourist traffic in the area of Kasprowy Wierch – research methods and problems]. *Współczesne Problemy i Kierunki Badawcze w Geografii* [*Contemporary Research Problems and Directions in Geography*], *2*, 33–47. Retrieved from: https://core.ac.uk/download/pdf/53116726.pdf (27.09.2022).

Instrukcja Urządzania Lasu część I (2011) [Forest Management Instruction, part I (2011)]. Warszawa: Państwowe Gospodarstwo Leśne Lasy Państwowe.

Janeczko, E., & Woźnicka, M. (2009). Zagospodarowanie rekreacyjne lasów Warszawy w kontekście potrzeb i oczekiwań mieszkańców stolicy [Development of urban forest recreation of Warsaw in the context of the needs and expactation of the residents of the capital]. *Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej* [*Studies and Materials of the*

✉m.ciesielski@ibles.waw.pl, ✉m.tkaczyk@ibles.waw.pl, ✉a.haidt@ibles.waw.pl, ✉maciej.szewczyk@ug.edu.pl, ✉patryk.waraksa@zilp.lasy.gov.pl

Nature and Forest Education Center], *4*(23), 131–139. Retrieved from: http://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-article-35074178-2331-4190-8d8d-d2ddfab5cce0?q=bwmeta1.element.agro-number-ade94e6b-82fb-4018-b384-c0144315787b;16&qt=CHILDREN-STATELESS 13.04.2022).

Janowsky, J., & Becker, G. (2003). Characteristics and needs of different user groups in the urban forest of Stuttgart. *Journal for Nature Conservation*, *11*(4), 251–259. https://doi.org/10.1078/1617-1381-00056.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*, 169–182. https://doi.org/10.1016/0272-4944(95)90001-2.

Kienast, F., Degenhardt, B., Weilenmann, B., Wäger, Y., & Buchecker, M. (2012). GIS-assisted mapping of landscape suitability for nearby recreation. *Landscape and Urban Planning*, *105*, 385–399. https://doi.org/10.1016/j.landurbplan.2012.01.015.

Lupp, G., Förster, B., Naumann, J. Honert, C., Kantelberg, V., Koch, M., & Pauleit, S. (2016). Using trigger trail cameras for visitor monitoring – Applications in Bavaria. In D. Vasiljevic (Ed). MMV 8 Abstract Book. Proceedings: Monitoring and Management of Visitors i Recreational and Protected Areas 26–30.09.2016, Novi Sad, pp. 277–279.

Lupp, G., Kantelberg, V., Förster, B., Honert, C., Naumann, J., Markmann, T., & Pauleit, S. (2021). Visitor Counting and Monitoring in Forests Using Camera Traps: A Case Study from Bavaria (Southern Germany). *Land*, *10*, 736. https://doi.org/10.3390/land10070736.

Lyon, K., Cottrell, S.P., Siikamaki, P., & van Marwijk R.B.M. (2011). Biodiversity hotspots and visitor flows in Oulanka National Park, Finland. *Scandinavian Journal of Hospitality and Tourism*, *11*, 100–111. https://doi.org/10.1080/15022250.2011.629909.

Meijels, E.W., de Bakker, M., Groote, P.D., & Barske, R. (2014). Analysis hiker movement patterns using GPS data: Implications for park management. *Computers, Environmental and Urban Systems*, *47*, 44–57. https://doi.org/10.1016/j.compenvurbsys.2013.07.005.

Nielsen, A., Heyman, E., & Richnau, G. (2012). Liked, disliked and unseen forest attributes: Relation to modes of viewing and cognitive constructs. *Journal of Environmental Management*, *113*, 456–466. https://doi.org/10.1016/j.jenvman.2012.10.014.

Paschalis-Jakubowicz, P. (2005). Lasy i leśnictwo polskie w Unii Europejskiej – oczekiwania i niepokoje [Polish forests and forestry in the European Union – expectations and concerns]. In *Społeczny wymiar lasów* [*Social dimension of forests*] (pp. 53–67). Warszawa: CILP.

Pietilä, M., Neuvonen, M., Borodulin, K., Korpela, K., Sievänen, T., & Tyrväinen, L. (2015). Relationship between exposure to urban green spaces, physical activity and self-rated health. *Journal of Outdoor Recreation and Tourism*, *10*, 44–54. https://doi.org/10.1016/j.jort.2015.06.006.

Prędki, R. (2012). Ruch turystyczny w Bieszczadzkim Parku Narodowym w latach 2009–2011 [Tourist traffic in the Bieszczady National Park in 2009–2011]. *Roczniki Bieszczadzkie* [*Annals of the Bieszczady Mountains*], *20*, 358–377. Retrieved from: http://agro.icm.edu.pl (13.04.2022).

Rice, W.L., & Pan, B. (2021). Understanding changes in park visitation during the COVID-19 pandemic: A spatial application of big data. *Wellbeing, Space and Society*, *2*, 100037. https://doi.org/10.1016/j.wss.2021.100037.

Rogowski, M. (2017). System Monitoringu ruchu turystycznego (SMrt) w Parku Narodowym Gór Stołowych – założenia i wybrane wyniki [Tourist Traffic Monitoring System (SMrt) in the Stołowe Mountains National Park – assumptions and selected results]. *Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej Rogów* [*Studies and Materials of the Rogów Nature and Forest Education Center*], *52*, 158–165. Retrieved from: http://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-4cfe0be5-8727-4c95-8dea-ebe3526da68f (13.04.2022).

Rogowski, M. (2018). System monitoring ruchu turystycznego (SMRT) w Parku Narodowym Gór Stołowych dla potrzeb badań przestrzeni turystycznej [Monitoring System of tourist traffic (SMtt) in the Stołowe Mountains National Park in the research on tourism spaces]. *Prace i Studia Geograficzne* [*Studies in Geographie*], *63*(3), 153–172. Retrieved from: https://wgsr.uw.edu.pl/pisg/?p=804 (27.09.2022).

Rogowski, M. (2020). Monitoring System of tourist traffic (MSTT) for tourists monitoring in midmountain national park, SW Poland. *Journal of Mountain Science*, *17*. https://doi.org/10.1007/s11629-019-5965-y.

Roovers, P., Hermy, M., & Gulinck, H. (2002). Visitor profile, perceptions and expectations in forest from a gradient of increasing urbanization in central

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Belgium. *Landscape and Urban Planning*, *59*, 129–145. https://doi.org/10.1016/S0169-2046(02)00011-7.

Rozporządzenie Nr 52/93 Wojewody Bydgoskiego z dnia 16 lutego 1993 r. w sprawie utworzenia parku krajobrazowego pod nazwą "Wdecki Park Krajobrazowy" [Regulation No. 52/93 of the Voivode of Bydgoszcz on the creation of a landscape park called "Wdecki Landscape Park" of February 16, 1993, Journal of Laws Bydgoszcz Voivodeship of 1993 vol. 10, item 133] (Poland).

Samołyk, M. (2013). Geocaching – nowa forma turystyki kulturowej [Geocaching – a new form of cultural tourism]. *Turystyka Kulturowa* [*Cultural Tourism*], *11*, 17–31. Retrieved from: http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.desklight-9b4b6728-cd8c-493a-b0bd-4101e2dc2c2b (13.04.2022).

Seeland, K., Moser, K., Scheuthle, H., & Kaiser, F. (2002). Public acceptance of restrictions imposed on recreational activities in the peri-urban Nature Reserve Sihwald, Switzerland. *Urban Forestry & Urban Greening*, *1*, 49e57. https://doi.org/10.1078/1618-8667-00006.

Skłodowski, J., Gołos, P., Skłodowski, M., & Ożga, W. (2013). Preferencje osób odwiedzających wybrane kompleksy leśne w zakresie turystyki leśnej i organizacji wypoczynku [Preferences of people visiting selected complexes forestry in the field of forest tourism and organization of recreation]. *Leśne Prace Badawcze* [*Forest Research Paper*], *74*, 293–305.

Spychała, A., & Graja-Zwolińska, S. (2014). Monitoring ruchu turystycznego w parkach narodowych [Monitoring of tourist traffic in national parks]. *Barometr Regionalny. Analizy i prognozy* [*Regional Barometer. Analyzes and forecasts*], *4*(38), 171–177. Retrieved from: http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.desklight-71de0d70-40a0-48cc-934c-ea4c5f873b80 (13.04.2022).

Staats, H., Kievie, A., & Hartig, T. (2003). Where to recover from attentional fatigue: an expectancy-value analysis of environmental preference. *Journal of Environmental Psychology*, *23*, 147–157. https://doi.org/10.1016/S0272-4944(02)00112-3.

Taczanowska, K., Muhar, A., & Brandenburg, C. (2008). Potential and limitations of GPS tracking for monitoring spatial and temporal aspects of visitor behaviour in recreational areas. In A. Raschi, & S. Trampetti (Eds.). *Management for protection and sustainable development* (pp. 451–455). Montecatini: Conciglio Nationale della Ricerche.

Taczanowska, K., Latosińska, B., Hibner, J., Czachs, C., Monteiro Neto, L., Muhar, A., & Brandenburg, C. (2017). Opracowanie mierników i narzędzi pomiaru efektywności wykorzystania obiektów turystycznych lasów państwowych – sprawozdanie końcowe z realizacji tematu badawczego nr 20/15 [Creation of Indicators and Tools for Measuring the Usage Effectiveness of State Forests' Tourist Infrastructure – final Report] (p. 336). University of Natural Resources and Life Sciences Vienna.

Taczanowska, K., Latosińska, B., Czachs, C., Hibner, J., Muhar, A., Brandenburg, C., & Rothert, M. (2018). Towards standards for quantification of recreational use in forest areas – indicators and data collection tools applied by the State Forests National Forest Holding, Poland. In D. Jeoffrey, G. Lambert, L. Ginelli, & K.B. Abdallah (Eds.). The 9th International Conference on Monitoring and management of visitor flows in recreational and protected areas (MMV9). Abstract book. *Place, recreation and local development*, (pp. 481–483), 21–30.08.2018, Bordeaux.

Tomalak, M. (2006). Postrzeganie drzew, szkodników oraz zabiegów ochrony roślin na obszarach parków i lasów miejskich [Perception of trees, pests and plant protection treatments in parks and urban forests]. *Postępy w Ochronie Roślin* [*Advances in Plant Protection*], *46*(1), 337–343. Retrieved from: https://www.researchgate.net/publication/272418320_Postrzeganie_drzew_szkodnikow_oraz_zabiegow_ochrony_roslin_na_obszarach_parkow_i_lasow_miejskich (13.04.2022).

Ugolini, F., Massetti, L., Calaza-Martínez, P., Cariñanos, P., Dobbs, C., Krajter Ostoic, S., Marin, A., Pearlmutterf, D., Saaroni, H., Šauliene, I., Simoneti, M., Verlič, A., Vuletić, D., & Sanesi, G. (2020). Effects of the COVID-19 pandemic on the use and perceptions of urban green space: An international exploratory study. *Urban Forestry & Urban Greening*, *56*, 1–9. https://doi.org/10.1016/j.ufug.2020.126888.

Ulrich, R.S. (1981). Natural versus urban scenes. Some psychophysiological effects. *Environment and Behavior*, *13*(5), 523–556. https://doi.org/10.1177/0013916581135001.

Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*, 201–230. https://doi.org/10.1016/S0272-4944(05)80184-7.

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Verlič, A., Arnberger, A., Japelj, A., Simončič, P., & Pirnat, J. (2015). Perceptions of recreational trail impacts on an urban forest walk: A controlled field experiment. *Urban Forestry* & *Urban Greening*, *14*, 89–98. https://doi.org/10.1016/j.ufug.2014.12.004.

Weingarth, K., Zimmermann, F., Knauer, F., Heurich, M. (2013). Evaluation of six digital camera models for the use in capture-recapture sampling of Eurasian Lynx (Lynx Lynx). *Waldökologie Landschaftsforschung und Naturschutz*, *13*, 87–92. Retrieved from: https://d-nb.info/1038111439/34 (27.09.2022).

Willberg, E.S., Tenkanen, H., Poom, A., Salonen, M., & Toivonen, T. (2021). Comparing spatial data sources for cycling studies – a review. *SocArXiv ruy3j, Center for Open Science*, 169–187. Retrieved from: https://ideas.repec.org/p/osf/socarx/ruy3j.html (13.04.2022).

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