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Temporal variability in the tourist traffic volume in Tatra National Park and its determinant

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Abstract. The article presents the results of research into the reasons for temporal variability in tourist traffic volume in the most visited national park in Poland in 2021 – a record year in terms of visitor numbers. Data on the daily sales of admission tickets were used alongside meteorological data, supported by PS IMAGO PRO software for multiple linear regression analysis. The results demonstrate that the tourist traffic volume did not only depend on the occurrence of weekends, public holidays and the summer holiday season, but also on a number of meteorological factors. The significance of the meteorological factors varied both by month and by day of the week. It was also different at different points of ticket sales, which provided some information about the visitor profiles and weather preferences of tourists choosing particular hiking trails. It was further found that, in summer, tourist traffic increases particularly on the first few days following a period of heavy rain.

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Contents:

1. Introduction

Mountain tourism is one of the most weather-sensitive forms of tourism (Kubokawa et al., 2014). Weather can both facilitate and limit the spending of leisure time in the mountains (Scott and Lemieux, 2010), as specific weather conditions are the basis for certain activities and attractions (e.g., the presence of snow for skiing). At the same time, climate change requires that the infrastructure in high mountain areas be adapted to changing conditions (Steiger et al., 2022). In the recent scorching-hot summers, increasing numbers of tourists have been looking to the mountains for cooler weather (Serquet & Rebetez, 2011).

All mountain national parks in Poland enjoy a huge tourist interest. The only other parks with comparable visitor numbers are the largest parks near urban agglomerations (Partyka, 2010, Widawski & Jary, 2019). Tourist's activity in the mountains is most often motivated by cognitive, aesthetic or sporting aspects (Mokras-Grabowska, 2016). In 2020, the year of the Covid-19 pandemic, tourist traffic was considerably restricted in both kinds of parks. However, the periods when restrictions on travel and social distancing were lifted showed the great importance of parks for people and their wellbeing. The lack of sense of security combined with problematic border-crossing procedures resulted in an increase in individual domestic trips (Matczak & Szymańska, 2023). The accessibility of conservation areas (considered safe) gained appreciation among people trying to relieve stress caused by the pandemic (Ma et al., 2021). There were sharp increases in tourist traffic (especially in summer) in many protected areas in Europe (McGinlay et al., 2020).

A crowd of people on a trail has various implications and can even pose a threat to the people themselves. Such situations are undesirable from the point of view of both nature conservation and trail maintenance, because intensive tourist traffic and skiing accelerates morphogenetic processes (Monz et al., 2010). The greatest transformation of topography as a result of excessive tourist traffic is observed along wide ridgelines in the alpine zone (Fidelus-Orzechowska et al., 2021).

The aim of this article is to investigate the meteorological conditions that determine the intensity of tourist traffic in Tatra National Park. Determining the factors affecting tourist traffic is crucial to managing protected areas, given the influence of such traffic on specific components of the natural environment (Clivaz et al., 2004). Tourist traffic in the Polish Tatra Mountains, especially in summer, significantly exceeds the absorbency and capacity of the tourist trails (Mokras-Grabowska, 2016). A number of authors have pointed out some correlations between tourist traffic volumes and prevailing meteorological conditions (Ploner & Brandenburg, 2003, de Freitas, 2003, Scott et al., 2007, Scott et al., 2008, Buckley & Foushee, 2012, Steiger et al., 2016, Fidelus-Orzechowska et al., 2017, Smith et al., 2018), particularly rain and temperature. Having reliable data on the determinants and the volume of tourist traffic makes it possible to evaluate the influence of tourists on the natural environment and to control the tourist traffic in such a way as to minimise its negative impact on nature (Fleuler & Hunziker, 2007). This could be used for planning maintenance interventions on tourist trails such that the disturbance to park visitors is largely reduced.

2. Research area

The area of the Tatra Mountains and Tatra National Park (TNP) is a tourism hub with an exceptionally high volume of tourist traffic. The number of visitors to TNP is increasing year by year. The greatest increases in tourist traffic were observed in the 1970s and then from the mid-90s. The total area of the park (established in 1955) is 21.2 km^2, and the total length of tourist trails is 275 km. Before the Covid-19 pandemic, the annual sales of admission tickets exceeded 3.7 million. TNP is therefore one of the smallest national parks in Europe, yet with very high tourist traffic volumes (Pociask-Karteczka et al., 2008). The major attractions of the park include the high-mountain landscapes with glacial landforms, waterfalls, mountain lakes (with Morskie Oko considered to be the most beautiful), unique fauna and flora, and hundreds of caves, as well as opportunities for climbing, skiing and hiking. Hiking is especially evident in a few areas of the park: the traffic is concentrated on the trail from Łysa Polana towards Morskie Oko (where you can continue hiking to the highest peak in Poland, on the top of Mt. Rysy, 2,499 m a.s.l.), the trail in the Kościeliska Valley, and the area of Mt. Kasprowy Wierch, which can be reached by cable car. For years, these three areas have together accounted for about 30% of total local tourist traffic annually. The traffic is also voluminous in the valleys within TNP – on trails that lead to a few mountain shelters located there (Fidelus-Orzechowska et al., 2017).

The pandemic of 2020 and its resulting restrictions caused the tourist traffic within the park to drop considerably (visitors from outside the Tatra County

were banned from entering the park from 13 March to 4 May) (Zbucki, 2023). The number of admissions dropped by over 400,000 compared with the year 2019. As a result of reduced human pressure, the quality of water in streams improved in the areas where access was restricted the most during the pandemic (Lenart-Boroń et al., 2022). Nevertheless, in the subsequent year the park was visited by a record number of tourists – 400,000 more than was predicted for 2021 or was expected based looking at on the growing trends (https://tpn.pl/zwiedzaj/turystyka/statystyka, accessed on 20.02.2024), and Tatra National Park along with other national parks 'benefitted' from the nationwide health crisis.

3. Materials and methods

The article presents the result of analysis of the relationship between tourist traffic volumes within TNP, understood as the total number of admission tickets sold, a number of meteorological parameters considered by the author to be the most significant, and individuals days of the week.

3.1. Materials

There are many methods for measuring tourist traffic volume that include: direct observation; survey methods (Steiger, 2016); methods based on hotel occupancy, passenger traffic, admission ticket sales and resort taxes (Alejziak, 2009); methods employing electronic devices such as cameras and pyroelectric detectors (Hibner, 2014); and methods that involve GSM location tracking of tourists (Alejziak, 2009).

In this paper, information on total daily sales of admission tickets provided by TNP was used (i.e., daily traffic volume, N). The analysis comprised data series from eight points of sale (POSs) identified in Figure 1, as follows: Dolina Kościeliska (1), Mała Łąka (2), Dolina Strążyska (3), Dolina Białego (4), Kalatówki (5), Goryczkowa (6), Jaworzynka (7) and Łysa Polana (8).

The POSs selected for analysis were open all year (other ticket offices was open seasonally or – as in the case of Mt. Kasprowy Wierch Cableway – can be temporarily closed due to adverse weather or for maintenance). Additionally, days on which one or more of the POSs were closed for various reasons were not included in the analysis (a total of 9 days). For the days and POSs selected for analysis, 2,389,513 tickets were sold altogether, which comprised 52% of the total sales in 2021. It was possible to buy admission tickets online, too, and such purchases accounted for 10% of the sales in 2021.

The data concerning meteorological elements was taken from the online weather service Meteomodel.pl (https://meteomodel.pl/ accessed 15.02.2024) for the Zakopane station. Ultimately, the following parameters were selected:

- Mean daily temperature (**T**, °C),
- Mean diurnal wind speed (**W**, m/s),
- Precipitation total (**P**, mm/day),
- Sunshine duration (**SD**, h), acknowledging the fact that maximum possible diurnal insolation is much greater in summer months than in winter. Therefore, the value of this parameter included seasonal changes in length of day,
- Cloud cover (**C**, measured in degrees from 0 to 8), mean daily value,
- Snow cover thickness (**SC**, cm),
- $\mathbf{p_f}$ – an additional, dimensionless weather improvement factor, based on the value of precipitation total (P) for the current day (d) and two preceding days (d-1, d-2), determined as follows:

$$p_f=(P_{d-2}\cdot P_{d-1}/P_d)^{0.5}$$

In order to avoid division by zero, where there is no precipitation on day P_d, a substitute value of 0.05 mm is introduced into the formula.

It was also assumed that tourist traffic volume can depend on the day of the week (D) and the days were therefore assigned appropriate numbers from 1 to 7.

3.2. Methods

The main part of the analysis was done using PS IMAGO PRO, which is a part of the IBM SPSS Statistics software package, licensed for use by the academic staff and students of the Nicolaus Copernicus University in Torun (NCU). The tool uses multiple linear regression to create models for evaluating relationships between a target variable and independent variables, perhaps removing those found to be irrelevant (backward elimination method). What we obtain are predicted values and their comparison with the actual value (data strings called 'residuals') and all information about the models created by the program, comprising:

- the value of the coefficient of correlation/determination of a given goodness of fit,
- information on which parameters were used in each case to develop an optimum model,
- values of the coefficients for independent variables, allowing for a presentation of the

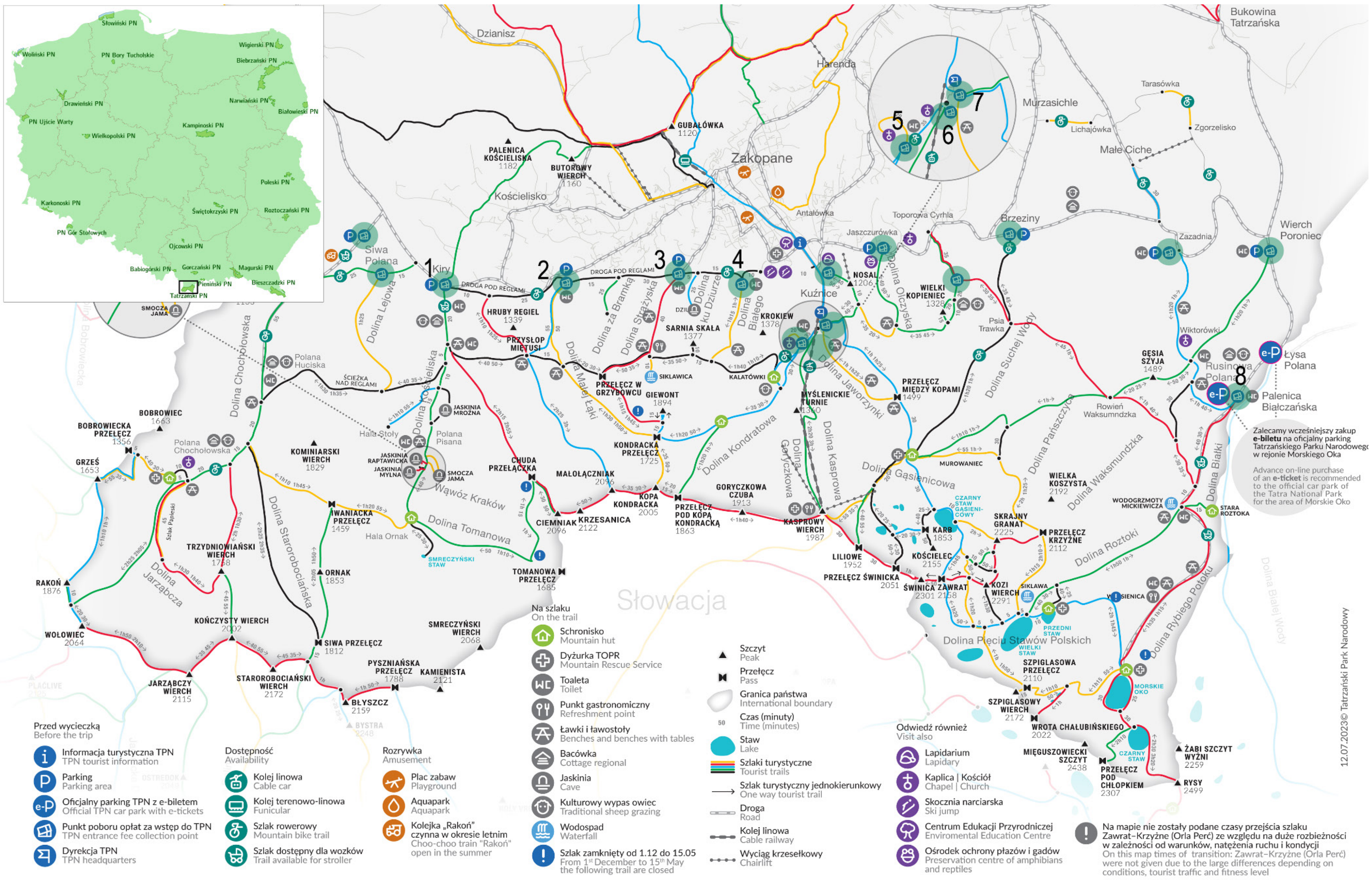

Fig. 1. Location of Tatra National Park (TNP), trails and tourist infrastructure, and points of sale of admission tickets. Numbers (see: text) identify POSs open all year that are considered in this paper

Source: https://upload.wikimedia.org/wikipedia/commons/5/5a/ParkinarodowePL.png, accessed on: 5.03.2024, edited

model in the form of a mathematical equation (Różycka & Pawłowski 2022).

The paper contains the results of the following analyses:

- Correlation between all eight parameters and the total number of admission tickets sold in a year, half-years (November–April and May–October) and individual months, and the annual and semi-annual correlation for the number of tickets sold for each of the selected points of sale,
- Determinants of the tourist traffic volume on weekdays and at weekends for the total number of tickets sold in a year and for each POS.

Using IBM SPSS Statistics, a total of 57 models were generated of the correlation between the number of tickets sold and the eight parameters (of which, seven were meteorological). The assumed uncertainty level for the independent variables was set at the standard p=95% in the models. Whenever the condition was not met, the parameters were removed from the model. When presenting the results, the 'standardised beta coefficient' was used. One advantage of the beta coefficient is the possibility to compare its value among various predictors in the model, regardless of the unit of measure (https://www.statisticshowto.com/beta-weight/ accessed 19.02.2024). This made it possible to identify which one was the most instrumental in predicting the value of a dependent variable. Furthermore, in each model the sum of their absolute values was reduced to the value of the determination coefficient. This enabled finding out which of the parameters contributed to what share of the tourist traffic volume (%).

4. Results

4.1. Basic information on tourist traffic in Tatra National Park and its temporal variability in 2021

The highest volume of the tourist traffic in Tatra National Park (TNP) was observed in August and July, and then in September and June (Fig. 2-A). Moreover, in each month from May until October (the warm season) the number of admission tickets sold was higher than in the months from November to April (the cold season). Within TNP, tourists visit the area in large numbers during weekends (especially on Saturday), whereas at the beginning of the week the numbers tend to be the smallest (on Monday), which trends are particularly marked in winter and autumn (Fig. 2-B). In the analysed year, traffic volume was lowest in April, whereas before the pandemic November and March the months of the lowest visitor turn-up.

4.2. Tourist traffic in individual seasons and its determinant factors

As expected, the increase in tourist traffic volume in the Tatra Mountains was directly proportional to the increase in air temperature, sunshine duration and pf and depended on the day of the week (excluding Saturday and Sunday), and it was inversely proportional to total precipitation, force of wind, and cloud cover. Snow cover thickness was a multidirectional factor.

In the case of the model covering all data for 2021, the mean daily air temperature was found to be the strongest determinant of the tourist traffic volume in TNP. This was largely because the warm season (July and August in particular) coincided with the holiday season. The second strongest determinant of the other variables was the day of the week (weekend tourist traffic), and the variables forming the model explained slightly more than 50% of the traffic volume (Fig. 3). The obtained mathematical formula was as follows:

$$N_p = 692.6D + 529.6T - 436C - 1889W - 112.1P + 111.4SC + 69.9p_f$$

The determinants in models for the winter half-year differed dramatically from those in the summer half-year model (Fig. 3). Specifically, in the winter half-year model, the day of the week was the most important, followed by cloud cover. In the summer half-year model, the most important factors for visitors were temperature and lack of rain.

The model obtained for the summer half-year, due to the concentration of tourist traffic in that period (Fig. 2), was more similar to the model for the whole year (i.e., it indicated the substantial influence of a large number of variables), but in the warm half-year precipitation came second (and the less rain, the better).

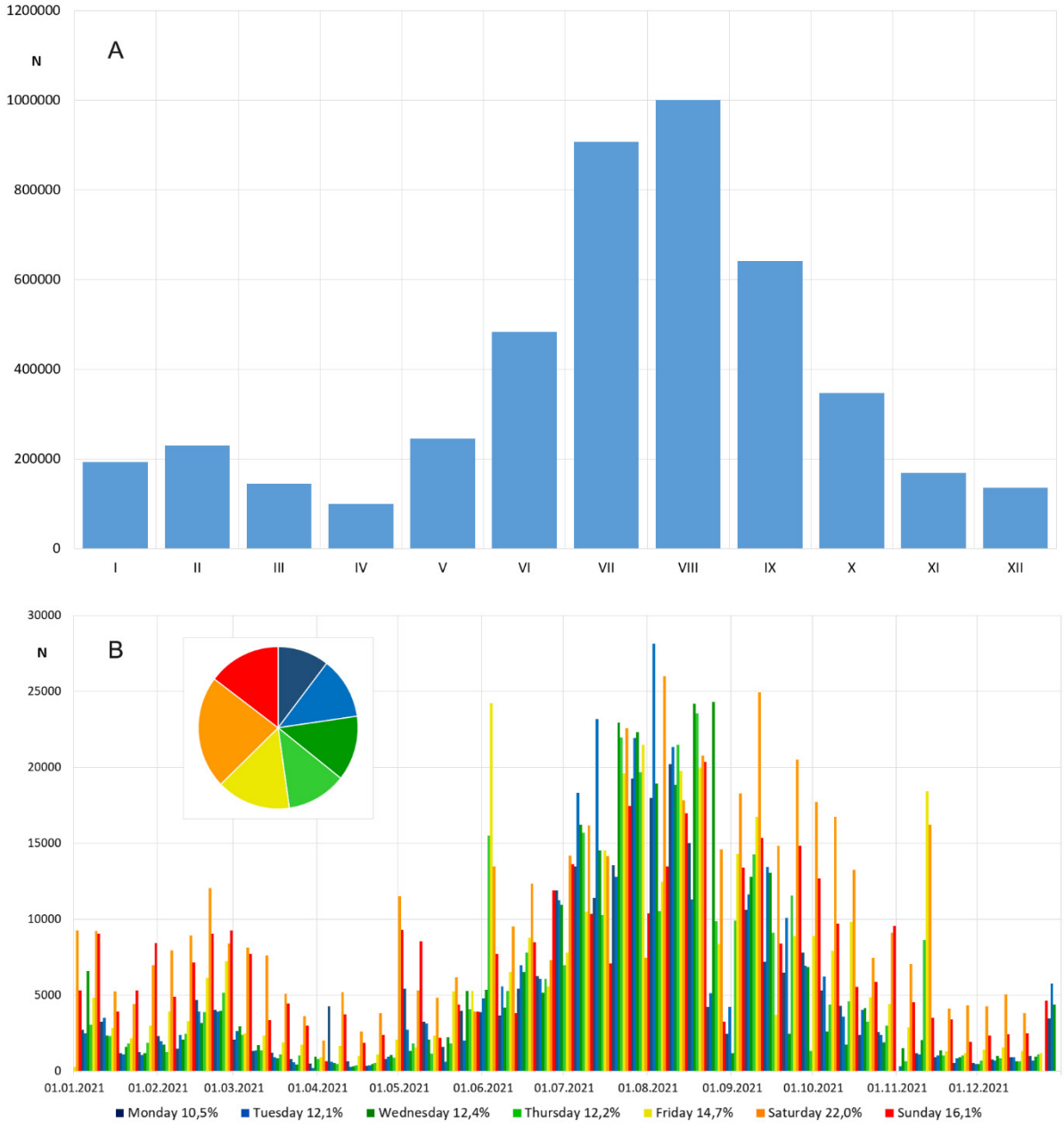

Fig. 2. Monthly (A) and daily (B) variability in tourist traffic volume in TNP in 2021
Source: authors' own elaboration based on TNP data

4.2.1. Tourist traffic volume models for individual months

First of all, it must be noted that, for nearly all models, air temperature was not considered as a factor determining traffic volume. This is perhaps explained by the fact that, in individual seasons and months, the temperature only changes within a limited range. Therefore, the results show that tourists hiking along the Tatra trails are prepared for such changes. If the temperature in July or August in the Tatra mountains ranged from -10°C to 25°C, an appropriate correlation would be evident. Thus, only the November model included the parameter of temperature. This might be because, in a month so unfavourable to outdoor tourism (only a thin snow cover, snow patches and possible icing), people generally choose the mountains only when it is still quite warm and safe. In the first half of the year (January–June), as in autumn (September–October), the weekends were the most decisive factor (though with different shares: 7–40%) determining traffic

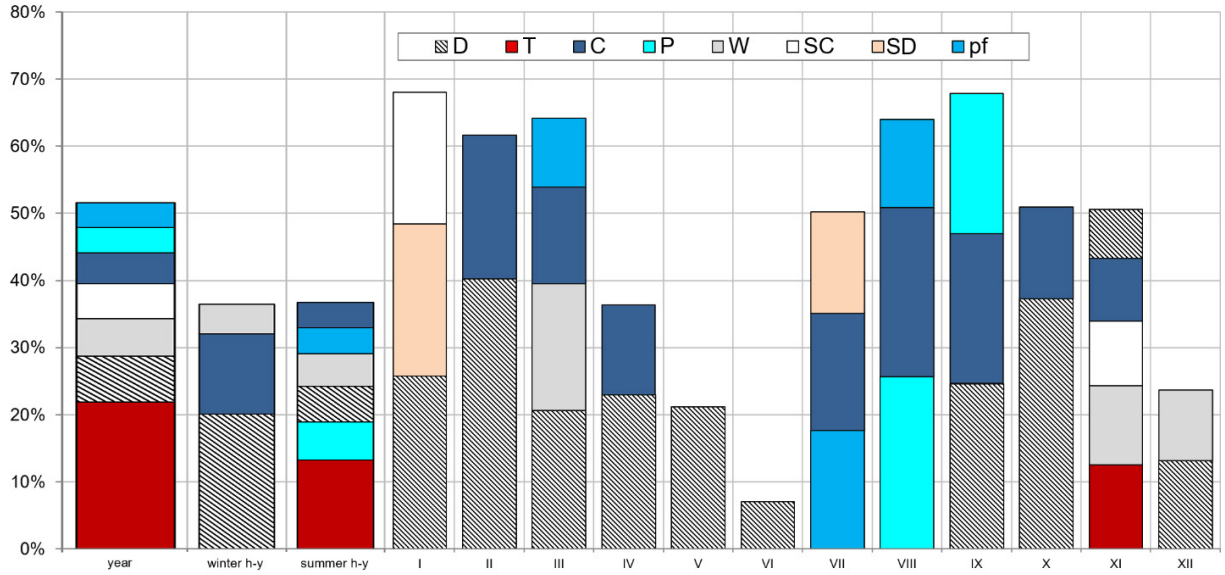

Fig. 3. Correlation of the tourist traffic volume in TNP with the analyzed variables. Explanations: D – day of the week, T – air temperature, C – cloud cover, P – precipitation, W – wind, SC – snow cover, SD – sunshine duration, p_f – precipitation factor. The height of the bar corresponds to the determination coefficient of the model (R^2)
Source: authors' own elaboration based on TNP and https://meteomodel.pl/ data, accessed: 15.02.2024

volume. Cloud cover was also found to play a major part then, as well as the wind in some of the winter months (Fig. 3). June and May turned out to be months in which the tourist traffic volume hardly depended on the analysed variables. This seemed to come from the fact that both months comprised additional public holidays contributing to 'long weekends' or 'bridge weekends' and were a time of organised trips to the Tatras (e.g., school trips).

In the second half of June in Poland, schools hold their end-of-year ceremonies, and students and parents do not normally go away at that time.

During summer holidays (July–August), the tourist traffic volume in TNP is shaped by other variables than in the rest of the year. The ticket offices selected for analysis sold an average of 15,607 admission tickets per day, and this value ranged from 2,467 to 28,138. The main factors determining the traffic volume were precipitation, followed by cloud cover and sunshine duration. In July, the most important parameter was pf, which expresses the degree of weather improvement (high values immediately after intensive rainfalls). On rainy days, most tourists decide against going to the mountains and prefer to visit museums or other cultural facilities, or simply to entertain themselves at restaurants or pubs. At the same time, they follow weather reports, waiting for an improvement in the weather so that they can 'make up'.

After summer holidays, the share of weekend tourists rapidly increased, yet the variables considered in the summer models (cloud cover and precipitation) still affected the number of daily admissions to the park (Fig. 3). The importance of snow cover should be mentioned here, as the thickness of snow cover in Zakopane turned out to be the only parameter whose influence was multidirectional (the parameter was considered in three models): in the main model (1) for the entire year and in the January model, the tourist traffic volume increased with the thickness of the snow cover. In November, higher values of this parameter in Zakopane tended to limit the traffic volume within TNP.

Sizeable underestimations of the daily number of tourists visiting TNP, as well as less frequent overestimations by the model (1), occurred only in the summer half of the year. Those exceeding the standard error value more than twofold are shown in Fig. 4. Among them, the most frequent were situations where a dramatic improvement in the weather followed a period of heavy rainfall in summer. Such situations (experienced by the author) were handled by the introduction of parameter pf. However, with large numbers of tourists waiting for the weather to improve during the summer peak season, the formula proved insufficient.

In a similar analysis carried out for the individual points of sale of tickets, the results (for

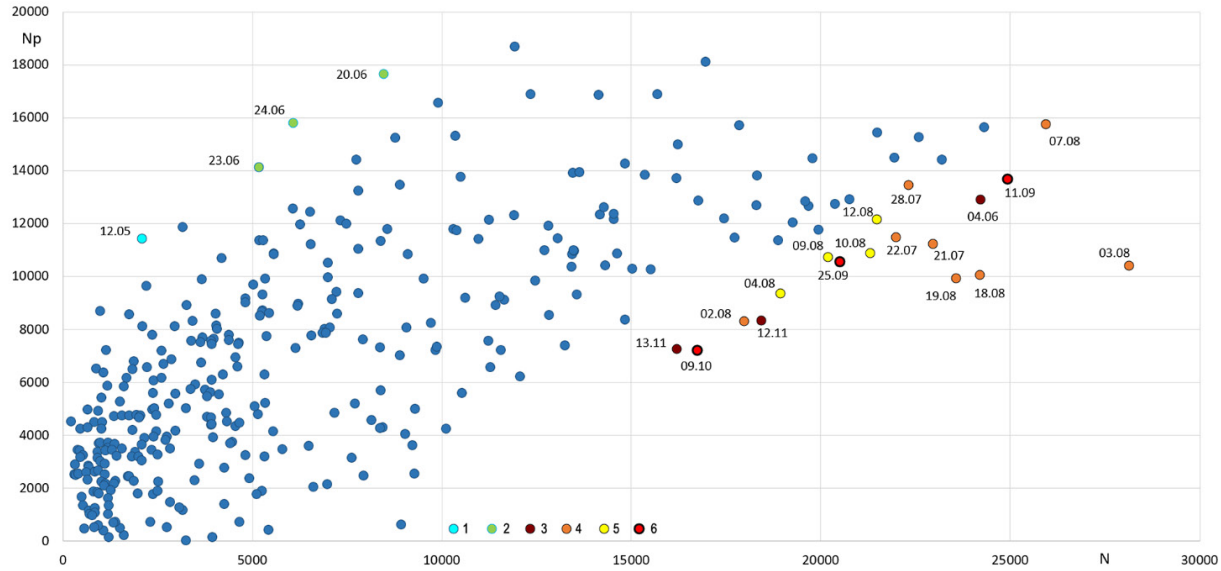

Fig. 4. Comparison of actual values of tourist traffic volume in the 2021 (N) with the results of a forecast obtained by means of a multiple regression model (N_p) and analysis of cases where the estimation error exceeded the standard error by a factor of two or more. Explanations: 1 – Mid-week, bad weather and a bad forecast for the coming days: rainfall, high winds; 2 – Days immediately before the end of the school year, a rainy week (P=43 mm) but also exceptionally hot, especially at the beginning and end; 3 – Extra days off during the so-called long weekends; 4 – The first two days of improved weather after a period of heavy rainfall in summer; 5 – Weekdays with favourable weather in the peak season; 6 – Beautiful and sunny Saturday, early autumn

Source: authors' own elaboration based on data from TNP data and www.meteomodel.pl, accessed on 15.02.2024

the year and half years) were – at all eight POSs – similar to the aggregate results shown in Fig. 3. The models reflecting the annual sum of ticket sales were built on the basis of six or seven parameters (excluding sunshine duration), and the value of the determination coefficient of those models ranged from R^2=0.38 to R^2=0.57. In each of the models, the included parameters ranked for size of influence as follows: air temperature (first), day of the week (second, except for POS Goryczkowa, where cloud cover was more important), then wind, snow cover and precipitation (however the order of the last three parameters varied across the models). Also, cloud cover and precipitation factor were considered in some of the models. The last of the parameters was omitted from only the model describing the determinants of tourist traffic volume above the POS Mała Łąka and from the summer seasons models for Dolina Białego, Dolina Strążyska and Kościeliska. This parameter was by far the most decisive in the case of Goryczkowa, which was the only point of entry to the park, where ticket sales in summer were the least dependent on the day of the week and air temperature.

4.3. Tourist traffic on weekdays and at weekends: individual ticket offices

The next part of the analysis compared the factors determining tourist traffic within TNP at the individual points of sale of admission tickets on weekdays and at weekends (Fig. 5).

The great significance of temperature was due to the inclusion of data for the whole year. By comparing the results obtained for all the points of sale, one can see that the models for weekends were built using far fewer variables (4.38 on average, as opposed to 6.6 for weekdays). At weekends at almost all points of sale, the day of the week was much more important, and tourist traffic was greater on Saturday than on Sunday (when most visitors go back home). At all the analysed points of sale of tickets, the volume of tourist traffic proved to be more correlated with air temperature on weekdays than at weekends. At weekends, this factor was not the prevailing one for three locations, where it was replaced by cloud cover, and, for one point of sale it was not even considered in the model at all (Fig. 5). The results demonstrate that tourists hiking at weekends (including long weekends) do not expect a favourable course of all the weather

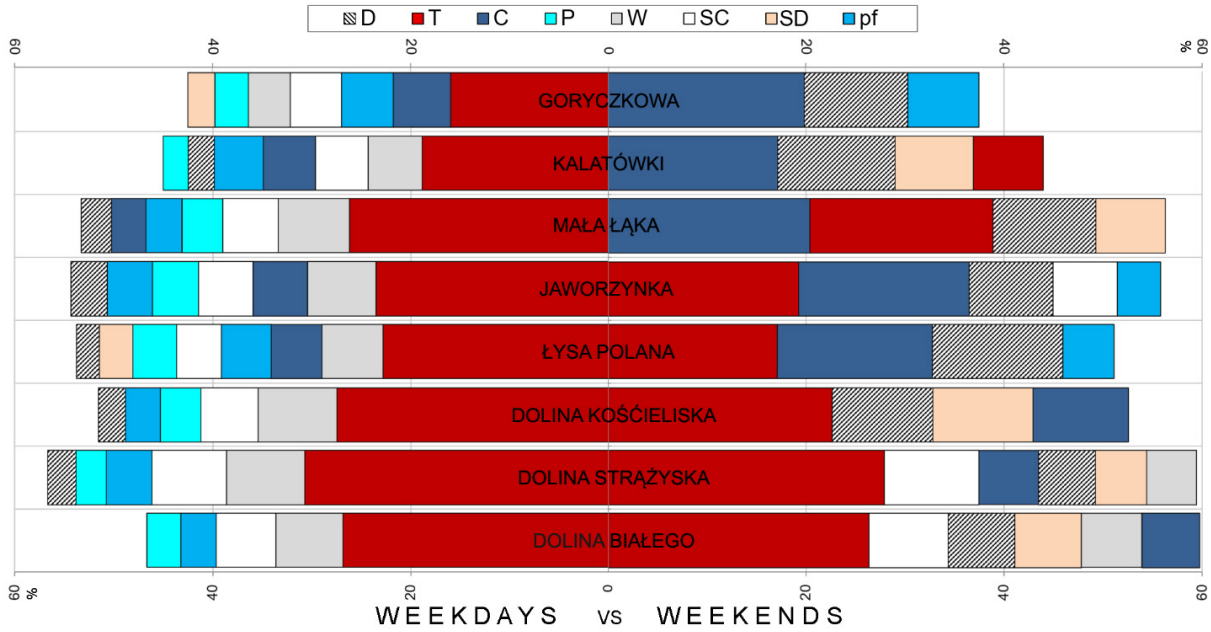

Fig. 5. Correlation between the volume of tourist traffic at the individual points of sale of tickets (weekdays and weekends) and the analysed variables. Explanations: D – day of the week, T – air temperature, C – cloud cover, P – precipitation, W – wind, SC – snow cover, SD – sunshine duration, p_f – precipitation factor. The length of the bar corresponds to the determination coefficient (R^2) of the model
Source: : authors' own elaboration based on TNP and https://meteomodel.pl/ data, accessed on: 15.02.2024

elements, and some, such as wind force, are hardly important to them. They try to use their short visit to TNP or the area of Zakopane as effectively as possible. These people are often unprepared for the conditions on the mountain trail, and their presence in the Tatra Mountains is driven by current fashion. Unfortunately, in the case of exceptionally unfavourable or dangerous weather conditions, such an approach may cause the number of accidents to increase, including fatal ones, as evidenced at the Easter weekend of 2024 when there were high foehn winds of up to 140 km/h in the Tatras (https://www.polsatnews.pl/wiadomosc/2024-04-01/wichury-w-tatrach-drzewo-przygniotlo-dziecko/ accessed on 02.04.2024).

5. Discussion

The points of sale of tickets in Figure 5 are not ranked at random. They are arranged according to the level of difficulty of the most popular trails above the points. At the bottom of the graph there are ticket offices where you enter valleys which do not require long and arduous hiking; there are no steep climbs to tackle and the scenic landscape and natural assets are the usual destination for visitors (even if the trails go on and join other routes). Moreover, two of them (Dolina Białego and Dolina Strążyska) are very near the centre of Zakopane. The ticket office in Dolina Kościeliska is located further from the town. The three valleys are normally selected for short trips. According to Hibner (2012), more than half of the visitors to Dolina Strążyska did not proceed any higher, and only 9% of the respondents declared that they would continue along the trail to Mount Giewont (1,894 m a.s.l.). In the case of Dolina Kościeliska, only 16% of tourists buying entrance tickets there declared they would go on, as the valley was not their goal (Fidelus-Orzechowska et al., 2017). The next ticket office in the set was situated at Łysa Polana; having bought an entrance ticket there, an absolute majority of tourists walk along the trail for 9 km only to see lake Morskie Oko. The subsequent points were the ticket offices where most tourists bought tickets to take the routes with greater height differences, in ascending order of difficulty: Jaworzynka (in the direction of Hala Gąsienicowa), Mała Łąka (Przysłop Miętusi, Czerwone Wierchy) and Kalatówki (Przełęcz pod

Kopą Kondracką, Mt. Giewont). The most 'alpine' was considered the ticket office Goryczkowa, being the starting point of the trail to the top of Mount Kasprowy Wierch (1,987 m a.s.l.). The trail, due to its nature and features (especially in the lower part), is rarely chosen for a stroll. As there are no other connecting trails (until you reach the top), tourists cannot take an alternative route mid-trip.

A clear decline in the significance of air temperature as the level of difficulty of the trails taken by tourists increased is a regular characteristics in the models presented in Figure 5. In the case of the most difficult routes, most tourists must have been exceptionally fit. This phenomenon was explained by Steiger et al. (2016) on the basis of survey research conducted in the German Alps. Tourists who practise sports or who are otherwise generally active physically are more tolerant of low temperatures or precipitation. One of the reasons for this may be that physical activity increases body temperature, and thus it is easier to tolerate lower air temperatures. Another reason may be that physical activity intrinsically motivates a person to take a hike in the mountains, so the tourist finds it easier to deal with unfavourable weather conditions. According to the researcher referred above, low temperatures are less tolerated by tourists visiting the mountains with children. In Tatra National Park, such tourists choose technically easier and shorter trips, entering the park and buying tickets at the points shown in the bottom part of Figure 5. Wlazło et al. (2015) found that most tourists taking difficult trails in the Tatras were men.

Weather affects the comfort of mountain tourism activities, and thus potentially influences the number of visitors (de Freitas, 2003). In the Tatras, warm weather and good visibility enhanced tourist traffic, whereas cold weather and precipitation reduced it – with extensive rainfall reducing it several-fold (Wlazło et al., 2015, Fidelus-Orzechowska et al., 2017). Outside the Tatra Mountains, a clear drop in the number of tourists as the air temperature decreases has been observed in Europe and the USA (Scott et al., 2007; Buckley & Foushee, 2012; Smith et al., 2018); however above 25°C, the number of active tourists in the mountains can decrease anyway. Such a regularity was ascertained when observing changes in bicycle traffic volumes in Toruń (Różycka & Pawłowski, 2022). It is difficult to validate because the models developed for the present study were based on mean daily temperature. Yet, where this parameter reached its highest values in Zakopane (24.9°C and 23.8°C) the aggregate value of traffic volume was clearly overestimated by the model (Fig. 4). This indicates that a very high temperature is not favoured by tourists in the Tatras, too. According to Steiger, Abegg & Janicke (2016), resistance to high temperature in the mountains varies for different groups of respondents (just like its optimum level and the lowest threshold of acceptability); it decreases with age and depends on whether children are brought for the hike. It was also lower in the group of first-time visitors as compared with returning tourists. In the case of mountain resorts (e.g., in the Alps and the mountains of Canada and New Zealand), the key factor determining traffic volume was rain and a subsequent cloudless period (Scott et al., 2008; Steiger et al., 2016). In the Tatras, this was also very prominent, and the sunny days following rainfall yielded record volumes of tourist traffic. Despite an attempt to consider such incidents by means of the additional precipitation factor (pf), the situations accounted for the greatest, even two-fold underestimation of the traffic volume in TNP by the model (Fig. 4).

The survey research into weather preferences carried out among tourists in German mountains in summer demonstrated that an absence of precipitation was the weather parameter that was always ranked first, followed by air temperature (Scott et al., 2008, Dubois et al., 2009) or sunshine (Steiger et al., 2016), i.e. the parameter describing cloudiness. In summer, the second of the cases applies to the Tatra Mountains in Poland (Fig. 3). It is noteworthy that the above-cited research results indicated that tourists prefer weather with some clouds to a clear blue sky (Scott et al., 2008, Steiger et al., 2016), which can be explained by the burdensome nature of continuous sunshine, especially at a high air temperature. The cited authors also argued that the strength of wind had little importance for tourists. As regards the results of research done for this paper, wind was quite important in some models developed for the cold half of the year. This is connected with the cooling action of the wind reducing the already low perceived temperature in the cold months, and the fact that the wind speed in the Tatras is nearly 50% greater in winter than in summer (Błażejczyk, 2019). In the present analysis, wind had the most influence on the tourist traffic volume in the Tatras at the beginning and the end of winter (Fig. 3). One possible explanation is that those were periods of transitional weather, and some tourists did not expect such a severe cold, either yet or anymore.

6. Conclusions

The main aim of the research was to determine the relationship between meteorological conditions and the intensity of tourist traffic in Tatra National Park. The undertaken analysis demonstrated the following:

- Although air temperature was found to be the most important determinant of tourist traffic volume in Tatra National Park over the year as a whole, in individual months tourists pointed to little cloud cover and an absence of precipitation as the most crucial meteorological parameters. This was particularly true for the summer holiday season;
- Also in the summer, the regular weekly pattern of tourist traffic (a minimum volume at the beginning of the week and a maximum on Saturday–Sunday) was the least visible;
- Overall, all the analysed parameters explained the size of tourist traffic volume in winter (January–March) and summer months (July–September) to the highest degree (the value of R^2). August proved to be the time when only the meteorological parameters determined nearly 65% of the tourist traffic;
- In the summer, in the first days of good weather following a period of intense rain, an unusual rush of tourists was observed on the Tatra trails, which could be compared to the bounce-back effect typical of periods of relaxation of pandemic-related restrictions. The phenomenon generated the biggest errors in the developed models. The results of this study can also offer a tip to tourists if they wish to avoid crowded trails while hiking in the Tatras. In such circumstances most tourists prefer longer trips higher up in the mountains, compensating for a period of physical inactivity. The rise tourist traffic was either small or absent on trails above the Mała Łąka ticket office;
- Comparing the parameters that determined tourist traffic volume at the different points of sale of tickets on weekdays and at weekends provided some very interesting results. As the level of difficulty and effort required to reach a chosen destination increased, the tourists tended to care less about air temperature, or even disregarded it at weekends, as was the case for the ticket office at the point of entry to the trail to Mt. Kasprowy Wierch. This shows that a model generated using multiple linear regression, and its components, may reveal the prevailing nature of trails above a given point of entry to the park, and provide some insight on the profile of tourists choosing each trail.

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References

Alejziak, W. (2009). TelSKART – nowa metoda badań oraz pomiaru wielkości ruchu turystycznego (TelSKART – a new method of research and measurement of the volume of tourist traffic – in Polish). *Folia Turistica, regiony turystyczne*, 21: 95-144.

Błażejczyk, K. (2019). Sezonowa i wieloletnia zmienność niektórych elementów klimatu w Tatrach i Karkonoszach w latach 1951–2015 (Seasonal and multiannual variability of selected elements of climate in the Tatra and Karkonosze Mts over the 1951–2015 period – in Polish). *Przegląd Geograficzny*, 91(1): 41–62. DOI: https://doi.org/10.7163/PrzG.2019.1.2.

Buckley, L.B. & Foushee, M.S. (2012). Footprints of climate change in US national park visitation. *International Journal of Biometeorology*, 56(6): 1173–1177. DOI: https://doi.org/10.1007/s00484-011-0508-4.

Clivaz, Ch., Hausser Y. & Michelet J. (2004). Tourism monitoring system based on the concept of carrying capacity-The case of the regional natural park Pfyn-Finges (Switzerland). *Working Papers of the Finnish Forest Research Institute*, 2: 230-235. Available at: www.metla.fi/julkaisut/workingpapers/2004/mwp002.htm.

de Freitas, C.R. (2003). Tourism climatology: evaluating environmental information for decision making and business planning in the recreation and tourism sector. *International Journal of Biometeorology*, 48(1): 45–54. DOI: https://doi.org/10.1007/s00484-003-0177-z.

Dubois, G., Ceron, J.P., van de Walle, I. & Picard, R. (2009). Climat, Météorologie et Fréquentation Touristique: Comportements et Stratégies des Touristes (Climate, Meteorology and Tourist Attendance: Tourist Behaviors and Strategies - in French). Ministère de l'Écologie, de l'Énergie, du Développement durable et de la Mer: Paris, France.

Hibner, J. (2012). Zróżnicowanie ruchu turystycznego w Tatrzańskim Parku Narodowym na wybranych przykładach (Diversity of tourist traffic in the Tatra National Park on selected examples in Polish). *Problemy Ekologii Krajobrazu. Rekreacja w krajobrazach o wysokim potencjale*, tom 34: 41–47.

Hibner, J. (2014). Monitoring ruchu turystycznego w rejonie Kasprowego Wierchu – metody i problemy badawcze (Monitoring of tourist traffic in the Kasprowy Wierch area – methods and research problems – in Polish), *Współczesne problemy i kierunki badawcze w geografii*, 2: 33-47.

Fidelus-Orzechowska J., Gorczyca E. & Krzemień K. (2017). Zróżnicowanie natężenia ruchu turystycznego w Tatrzańskim Parku Narodowym w latach 2000-2016 (Tourist volume in Tatra National Park in the years 2000-2016 – in Polish). In: M. Drewnik & M. Mika (ed.). *Człowiek i jego działania: spojrzenie geografa: prace dedykowane Profesorowi Włodzimierzowi Kurkowi*: 107-117. Wydawnictwo Instytutu Geografii i Gospodarki Przestrzennej UJ Kraków. Available at: https://tinyurl.com/58v4twyx.

Fidelus-Orzechowska, J., Gorczyca, E., Bukowski, M. & Krzemień, K. (2021). Degradation of a protected mountain area by tourist traffic: case study of the Tatra National Park, Poland. *Journal of Mountain Science*, 18(10): 2503-2519. DOI: https://doi.org/10.1007/s11629-020-6611-4.

Kubokawa, H., Inoue, T. & Satoh, M. (2014). Evaluation of the tourism climate index over Japan in a future climateusing a statistical downscaling method. *Journal of the Meteorological Society of Japan*, *Series II*, 92(1): 37–54. DOI: https://doi.org/10.2151/jmsj.2014-103.

Lenart-Boroń, A.M., Boroń, P.M., Prajsnar, J.A., Guzik, M.W., Żelazny, M.S., Pufelska, M.D. & Chmiel, M.J. (2022). COVID-19 lockdown shows how much natural mountain regions are affected by heavy tourism. *Science of the Total Environment*, 806(3): 1-14. DOI: https://doi.org/10.1016/j.scitotenv.2021.151355.

Ma, A.T.H., Lam, T.W.L., Cheung, L.T.O. & Fok, L. (2021). Protected areas as a space for pandemic disease adaptation: a case of COVID-19 in Hong Kong. *Landscape and Urban Planning*, 207: 103994. DOI: 10.1016/j.landurbplan.2020.103994.

Matczak, A. & Szymańska, D. (2023). The spatial structure of domestic tourist trips of Polish residents in the context of the Covid-19 pandemic. *Bulletin of Geography. Socio-economic Series*, 62(62): 43-57. DOI: http://doi.org/10.12775/bgss-2023-0033.

McGinlay, J., Gkoumas, V., Holtvoeth, J., Fuertes, R. F. A., Bazhenova, E., Benzoni, A., Botsch, K., Martel, C.C., Sanchez, C.C., Cervera, I., Chaminade, G., Doerstel, J., Garcia, C.J.F., Jones, A., Lammertz, M., Lotman, K., Odar, M., Pastor, T., Ritchie, C., Santi, S., Smolej, M., Rico, F.S., Waterman, H., Zwijacz-Kozica, T., Kontoleon, A., Dimitrakopulos, P.G. & Jones, N. (2020). The Impact of COVID-19 on the Management of European Protected Areas and Policy Implications. *Forests*, 11(1214): 1-15. DOI: https://doi.org/10.3390/f11111214.

Meteomodel. (2024). Available at: https://meteomodel.pl.

Mokras-Grabowska, J. (2016). Turystyka piesza górska w Tatrzańskim Parku Narodowym (Mountain hiking in the Tatra National Park – in Polish). *Turyzm*, 26(1): 73-81. DOI: http://dx.doi.org/10.18778/0867-5856.26.1.08.

Monz, C.A., Cole D.N., Leung Y.F. & Marion J.L. (2010). Sustaining visitor use in protected areas: future opportunities in recreation ecology research based on the USA experience. *Environmental Management*, 45: 551-562.

Partyka, J. (2010). Ruch turystyczny w polskich parkach narodowych (Tourist traffic in Polish National Parks – in Polish). *Folia Turistica*, 22: 9-24.

Ploner, A. & Brandenburg C. (2003). Modelling visitor attendance levels subject to day of the week and weather: a comparison between linear regression models and regression models and regression trees. *Journal for Natural Conservation*, 11: 297-308.

Pociask-Karteczka J., Baścik M. & Czubernat S. (2008). Ruch turystyczny w Tatrzańskim Parku Narodowym w latach 1993-2005 (Tourist traffic in the Tatra National Park in 1993-2005 – in Polish). In: W. Kurek & M. Mika (ed.). *Studia nad turystyką. Tradycje stan obecny i perspektywy badawcze*, 1.1: 271-279. Wydawnictwo Instytutu Geografii i Gospodarki Przestrzennej UJ Kraków. Available at: https://tinyurl.com/47pr6a37.

PolsatNews. (2024). Available at: https://www.polsatnews.pl/wiadomosc/2024-04-01/wichury-w-tatrach-drzewo-przygniotlo-dziecko/.

Różycka, K. & Pawłowski, B. (2022). Meteorological determinants of bicycle traffic volume in Toruń. *Bulletin of Geography. Socio-economic Series*, 58: 97-107. DOI: http://doi.org/10.12775/bgss-2022-0036.

Scott, D., Jones, B. & Konopek, J. (2007). Implications of climate and environmental change for nature-based tourism in the Canadian Rocky Mountains: A case study of Waterton Lakes National Park. *Tourism Management*, 28(2): 570–579. DOI: https://doi.org/10.1016/j.tourman.2006.04.020.

Scott, D., Gössling, S. & de Freitas, C.R. (2008). Preferred climates for tourism: case studies from Canada, New Zealand and Sweden. *Climate Research*, 45(1): 61–73. DOI: https://doi.org/10.3354/cr00774.

Scott, D. & Lemieux, C. (2010). Weather and climate information for tourism. *Procedia Environmental Sciences*, 1: 146–183. DOI: https://doi.org/10.1016/j.proenv.2010.09.011.

Serquet, G. & Rebetez, M. (2011). Relationship between tourism demand in the Swiss Alps and hot summer air temperatures associated with climate change. *Climatic Change*, 108(1–2): 291–300. DOI: https://doi.org/10.1007/s10584-010-0012-6.

Smith, J.W., Wilkins, E., Gayle, R. & Lamborn, C.C. (2018). Climate and visitation to Utah's "Mighty 5' national parks. *Tourism Geographies*, 20(2): 250–272. DOI: https://doi.org/10.1080/14616688.2018.1437767.

Steiger, R., Abegg, B. & Janicke, L. (2016). Rain, rain, go away, come again another day. Weather preferences of summer tourists in mountain environments. *Atmosphere*, 7(63): 1-12. DOI: https://doi.org/10.3390/atmos7050063.

Steiger, R., Knowles, N., Pöll, K. & Rutty, M. (2022). Impacts of climate change on mountain tourism: a review. *Journal of Sustainable Tourism*: 1-34. DOI: https://doi.org/10.1080/09669582.2022.2112204.

Tatrzański Park Narodowy portal. (2024). Available at: https://tpn.pl/zwiedzaj/turystyka/statystyka.

Widawski, K. & Jary, Z. (2019). Mass tourism in protected areas – underestimated threat? Polish National Parks case study. *Open Geosciences*, 11: 1046–1060. DOI: https://doi.org/10.1515/geo-2019-0081.

Wikipedia. (2024). Available at: https://upload.wikimedia.org/wikipedia/commons/5/5a/ParkinarodowePL.png.

Wlazlo, E., Franczak, P., Poltorzecki, K. & Dolezuchowicz, M. (2015). Ruch turystyczny na szlaku Czarny Staw–Rysy w Tatrach. Profil turystów i ich oddziaływanie na przyrodę Tatrzańskiego Parku Narodowego. . (Tourist traffic on the Czarny Staw – Rysy trail in the Tatra Mountains. Profile of tourists and their impact on the nature of the Tatra National Park – in Polish). *Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej*, 17(4): 45.

Zbucki, Ł. (2023). Wpływ pandemii koronawirusa Sars-coV-2 na ruch turystyczny w polskich parkach narodowych (The impact of the Sars-CoV-2 Coronavirus pandemic on tourist traffic in Polish national parks – in Polish). Biała Podlaska: Wydawnictwo AB JPII.