VISITS IN FORESTS DURING THE COVID-19 PANDEMIC IN THE CROSS-BORDER AREA OF POLAND, THE CZECH REPUBLIC AND GERMANY

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Abstract: Mobile phone data were used to examine the differences in the number and structure of visitors to the Forest Promotion Complex *Sudety Zachodnie* in 2019 (pre-pandemic year) and 2020 (pandemic year). The studies not only compared the total number of visitors in each year, but also distinguished four pandemic and restriction periods. This allowed us to capture the dynamics of the impact of the pandemic on visits to forest areas. The results show that although the total number of visitors increased in 2020 compared to 2019, different trends were observed in each pandemic period. In general, the number of visitors to forest areas decreased during the first lockdown, as well as during the ban on entering green areas and forests. However, during the easing of restrictions and the second lockdown in the fall of 2020, there was an increase in visitor numbers. The article also shows the evolution of visitor numbers at a very detailed level of a grid of 750 × 750 m. During the pandemic, the structure of visitors also changed taking into account the place of residence. Local tourism was more important than national tourism. A significant decrease in the number of visitors from abroad was also observed, which is a consequence of the introduced restrictions on travel between countries.
The methodology presented in this article can be used not only to study the impact of the pandemic on visits in forest, but also to manage forest areas with a view to adapting forest management to the needs of society.

Keywords: COVID-19, forest use, recreation, mobile data, forests

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Introduction

The importance of the availability of green areas and spending time in them has been consistently highlighted in sociological and psychological research findings (Bielinis et al. 2019; Furuyashiki et al. 2019). It has been known for a long time that contact with nature has a positive effect on human health and well-being, can lower stress levels or even reduce mortality (Barboza et al. 2021). Green areas play a major role in ensuring recreation, especially for urban dwellers (van den Berg et al. 2003; Nielsen et al. 2017; Baumeister et al. 2020). However, limited number of green areas causes the inhabitants of these spaces to look for other places of recreation. Forest areas are a natural place where it is possible to fulfil one of the basic human needs, which is contact with nature through active and passive

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recreation (Ciesielski, Stereńczak 2018). Tourism in forest areas is called silva tourism. This term refers to any type of traffic whose destination is forest areas (Muszyński, Kozioł 2013). Research on recreational use of forest areas, conducted for nearly half a century, has provided extensive insights into society's preferences regarding the following:

1. the appearance of the forest and its surroundings (Edwards et al. 2012),
2. demand for recreation infrastructure (Koeml, Morawetz 2016),
3. motivations for choosing to rest in forest areas (Gołos 2013),
4. forest functions/ecosystem services and the role of forests (Hegetschweiler et al. 2022) and
5. factors disturbing recreation in forest areas (Heyman 2012).

The results of the surveys indicate that the non-productive functions of the forest (protective, social) are more important for society than the production function (Gołos 2013). Recent studies that move away from the function of the forest in favour of the concept of ecosystem services also emphasise that provisioning services are of very little importance to the inhabitants of cities and mountain areas (Bruzzese et al. 2022; Hegetschweiler et al. 2022). The importance of the social functions of the forest, including recreation and tourism in forest areas, has also been highlighted in legal provisions of the rank of act (Act of 1991) and internal regulations of the State Forests (including the Forest Management Manual 2012). Moreover, Ordinance (*Zarządzenie* 2022) indicate the possibility of designating zones of intensive and sustainable social impacts.

In recent years, the recreational function of forests has become extremely important, not only in the opinion of society but also of forest managers. Forest managers face the need to adapt forest areas for the needs of recreation, which is currently one of the challenges of forest management (Eggers et al. 2019). The growing demand for recreation in the forest led not only to conflicts between foresters and society, but also between various groups of forest users before the coronavirus disease (COVID-19) pandemic (Derks et al. 2020; Wilkes-Allemann et al. 2020). The reasons for the conflicts included different expectations of the society regarding forest management and investment in forest areas, as well as excessive traffic (recreation) in forests (Nousiainen, Mola-Yudego 2022).

The COVID-19 pandemic has led to many changes in people's lives, both in the private and professional spheres (Kang et al. 2020). Restrictions on movement introduced by governments, e.g., (1) #stay-at-home principle, (2) the closure of many sectors of the economy, such as services including cinema, theatre, hairdressers, beauticians and shopping malls, (3) the closure of nurseries, kindergartens and schools and the subsequent switch to distance learning, (4) the introduction of remote work on an unprecedented scale, and (5) the closure of sports facilities, changed our typical daily routines. Reduced mobility and physical activity were observed (Taylor et al. 2021), as well as less social contact (Latsuzbaia et al. 2020), while time flexibility and time spent in front of computers increased (Wong et al. 2021). The importance of local and national tourism also increased, at the expense of foreign travel (Volgger et al. 2021). The pandemic also had an impact on mental health (Fiorillo, Gorwood 2020). The introduced restrictions, as well as fear for health, caused people to experience negative emotions, stress, depression and feelings of helplessness (Serafini et al. 2020). As noticed by Sher (2020), prolonged isolation and confinement may also increase the risk of committing suicide. Considering all these circumstances, the role of green areas in improving human well-being has become even more evident (Dushkova et al. 2021; Zhang et al. 2021). During the pandemic, the demand for recreational opportunities in forests also increased (Derks et al. 2020; Pichlerová et al. 2021; Ciesielski et al. 2022). Recreation in forest areas and its accessibility have also been the subject of numerous debates at various levels of decision-making (Derks et al. 2020; Venter et al. 2020). However, as Weinbrenner et al. (2021) note, the outbreak of the COVID-19 pandemic and numerous restrictions implemented by national governments meant that society had to relearn how to relax in the forest. It is legitimate to wonder whether the change in behaviour will last and whether it will be necessary to create new forest management rules to meet social expectations and the increased number of visitors.

In order to make decisions about the impact of the pandemic on the use of forest areas, it was necessary to determine the volume of traffic there.

For this purpose, the use of natural areas has been monitored for many years. Despite the development of many monitoring techniques, there is still a search for new research methods that will allow five basic questions to be answered as accurately as possible. These questions are both quantitative and qualitative: where and when does recreation occur, who does it, what does it do and why? (Willberg et al. 2021) To answer the first two questions (where and when), various methods of direct and indirect monitoring have been used to date, including, e.g. pyroelectric sensors (Ciesielski et al. 2022), camera traps (Lupp et al. 2021), surveys (Gołos 2013), ticket registration data (Fisher et al. 2019) and Global Positioning System (GPS) data (Taczanowska et al. 2017). Surveys have also been the main tool in research in the area of analysing the behaviour and demographics of people visiting natural areas (the questions being 'Who? What does it do? Why does it do it?') (Pickering et al. 2018). A separate group of data and methods included those using the so-called big data resources. According to Manyika et al. (2011), we entered the era of big data when companies began to collect data from their customers and many devices were equipped with sensors. Therefore, big data resources are usually understood as large-scale data. However, as Miller and Goodchild (2015) point out, these comprise data that are beyond our ability to analyse. In terms of social mobility, big data created by users of mobile applications and social networks have been used: Flickr (Domènech et al. 2020; Ciesielski, Stereńczak 2021), Instagram (Tenkanen et al. 2017; Falk, Hagsten 2021; Grzyb et al. 2021), Strava (Venter et al. 2020), Twitter (Ghermandi, Sinclair 2019) and mobile phone data (Rice, Pan 2021). As Wang et al. (2018) point out, mobile phone data are an extremely valuable source for analysing the community mobility. The application of these data in natural areas was confirmed, e.g., by Merrill et al. (2020), who used them to estimate the number of tourists. Monz et al. (2019) point out that mobile phone data enable the creation of models of the relationship between people and the environment on an unprecedented scale. Tu et al. (2017) have identified zones of recreational use of spaces, and Xiao et al. (2019) have determined the availability of green areas. The effects of weather on cultural ecosystem services in urban protected areas were studied by Jaung and Carrasco (2021). Mobile phone data were also used to analyse the impact of the COVID-19 pandemic on community mobility in natural areas (Xiong et al. 2020; Rice, Pan 2021). Gao et al. (2020) used aggregated cell phone location data to examine the factors influencing changes in park visitation dynamics during the pandemic. Similar analyses were conducted by Rice and Pan (2021). The effects of restrictions on community mobility and recreation in protected areas were also studied by Kupfer et al. (2021). Galleguillos-Torres et al. (2022) have shown that the pandemic has exacerbated the problem of recreation demand, especially in cities where there is little space for recreation. In typical forest areas, mobile phone data were not used for analysing the effects of COVID-19 on recreation demand. However, it should be emphasised that numerous works regarding the area in question primarily used remote forms of survey (online, telephone) (Rice et al. 2020), user-generated data (Grzyb et al. 2021) and data from pyroelectric sensors (Rogowski 2021; Ciesielski et al. 2022). This was primarily due to the limitations introduced during the pandemic (limiting contacts, maintaining distance) and security.

In an attempt to fill this research gap and considering the potential of forests to provide a place for recreation, this article uses data from mobile phones registered in 2019–2020 to analyse the following changes:

1. Number of visitors to forest areas in 2019 (pre-pandemic) and 2020 (pandemic) and their age and gender structure;
2. Number of visits divided into pandemic periods and the introduced restrictions (four periods);
3. Structure of visitors, including subdivision into local, domestic and international tourists.

The analyses were conducted in the area of the Forest Promotional Complex *Sudety Zachodnie*.

Materials and methods

Study area

The study was conducted for forests managed by the State Forests and located on the territory of the Forest Promotional Complex *Sudety Zachodnie*. This area includes three forest subdistricts

located in the *Świeradów* Forest District (Fig. 1) and the *Szklarska Poręba* Forest District, which belong to the Regional Directorate of the State Forests in Wrocław. The Western Sudetes or *Sudety Zachodnie* is an area established by the order of the General Director of the State Forests on 14 October 2004. Forest promotional complexes in Poland play a special role in promoting sustainable forest management, in supporting scientific research and education, and in making the forest available to the public. The studied forest area is located in the immediate vicinity of the towns of *Świeradów-Zdrój* (which has the status of a spa) and *Szklarska Poreba*. These towns have a rich offer of accommodation. According to some estimates, in the Lubański and Karkonoski counties (Dolnośląskie Voivodeship), a total of 47,100 overnight stays per 1,000 inhabitants were provided in 2019, and in 2020 (pandemic), 34,500 stays were recorded (Statistics Poland 2022). According to surveys conducted in the Dolnośląskie Voivodeship (Lower Silesia) in 2019 using the computer-assisted telephone interview (CATI) method, almost 30% of respondents indicated nature-oriented values as an important tourist offer of the region and hiking in the mountains as a form of recreation they intend to use (the European Association of Consultants [EU-Consult] 2019). The natural attractions of the research area and its surroundings include the following:

1. Giant Mountains National Park, which can be reached by numerous hiking trails leading through the forests of the research area;
2. The Jizera Mountains, whose gentle shape enables hiking and biking. In its territory was created the *Izerski Park Ciemnego Nieba*, the first project of its kind in Poland and the Czech Republic;
3. *Torfowiska Doliny Izery Nature Reserve*, which is the largest complex of upland and transitional peatlands in the country. Hiking in the forest areas is possible owing to the extensive network of trails with a length of several hundred kilometres (e.g. *Główny Szlak Sudecki im. dr. Mieczysława Orłowicza* starts in *Świeradów-Zdrój*), so the area can be used for hiking, biking (including a single track with a total length of about 80 km) and skiing (the ski resort in Jakuszyce) throughout the year.

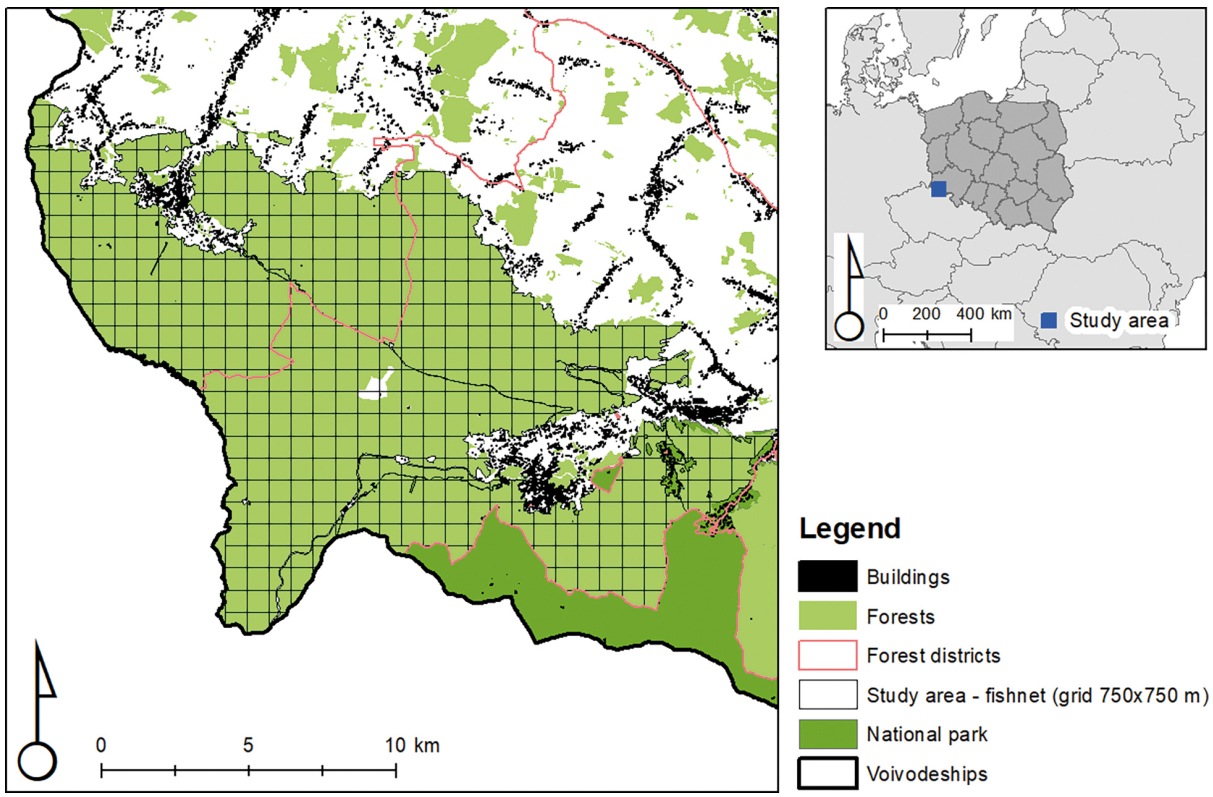

Fig. 1. Study area.
Source: own elaboration.

The tourist infrastructure also enables free traffic from the neighbouring countries of the study area, namely from the Czech Republic and Germany. Because of its location, scenic and natural values, as well as the developed infrastructure related to tourism and recreation, the area of the *Sudety Zachodnie* is a place of recreation all the year round.

Material

Commercial data recorded from mobile phone users were used for the analyses that cover the period from 1 January 2019 to 31 December 2020. The data were acquired from Selectivv Company, which collects data on the following: location of users, timestamps (information on events – e.g. receiving/sending messages through short message services (SMSs), making/receiving a phone call) generated by free applications used by users, whereby users consent to the collection of data in order to personalise the selection of advertising. The data distributor provides them after prior anonymisation (no personal data, no data transmission for basic fields for which the query results in <10 records).

For the purposes of the analyses, the following data were obtained for the forest areas in the selected basic fields:

- *Sudety Zachodnie* area – number of unique visitors per month; place of residence (night zone) – the place where the visitors most often stay between 10 pm and 6 am; structure of tourists by place of residence, broken down into local tourists (counties in the Dolnośląskie Voivodeship), domestic tourists (voivodeships in Poland) and international tourists; visitor profile (gender, age and interest in sports).
- Base field (size: 750 × 750 m) – the number of unique visitors in the same periods of the year before the pandemic (2019) and during the pandemic (2020). The periods were selected according to the restrictions introduced by the Polish government as follows: first lockdown (24–31 March 2020 and 20 April–3 May in 2020); no access to green areas (1–19 April 2020); easing of restrictions (the summer period was chosen, 1–31 July 2020); second lockdown (24 October–29 November in 2020). The visitor was registered once per day in the base field (one visit).

Data were collected only for forest areas located in the defined base fields.

Pandemic stage

In Poland, the first case of COVID-19 was registered on 4 March 2020, more than three months after the first case was registered worldwide. According to the decision of the Government of the Republic of Poland, preventive measures were introduced from 24 March 2020, in the form of a so-called full lockdown. During this period, restrictions were imposed in both economic and social spheres to reduce contacts: meetings, gatherings and events were restricted; leaving the house was allowed only in urgent cases (#stay-at-home principle); the use of public transport was restricted; the service sector was closed (e.g. hairdressers, shopping centres, restaurants, cinemas and theatres). In addition, a total ban on entering green areas and forest areas was introduced for the period 1–19 April 2020. Owing to widespread dissatisfaction among the population, this ban was lifted after 19 days, and the restrictions from before 1 April 2020 were reinstated. The first lockdown lasted until 3 May, the end of a long weekend in Poland. After that, the restrictions were gradually eased (4 May–16 October 2020). During this phase, international travel was still largely restricted, and the government encouraged people to travel through Poland and support the local economy. As a result of the second wave of the coronavirus in Poland, restrictions were implemented at county and voivodeship levels between 17 and 23 October 2020. A second lockdown was then implemented from 24 October to 29 November 2020. In this phase, the restrictions were similar to those of the first lockdown. The pandemic stages and restrictions presented were also used in the work of Ciesielski et al. (2022).

Statistical analysis

To examine the differences in forest use, the non-parametric Mann–Whitney *U*-test (corrected for continuity) was performed (p <0.05000). Differences were tested for analogous periods in the pre-pandemic year (2019) and the pandemic year (2020) in the following systems:

- first lockdown: 24 March–3 May in 2020 (without the ban to enter forest areas);

- ban on entering green areas and forests: 1–19 April 2020;
- easing of restrictions: 1–31 July 2020;
- second lockdown: 24 October–29 November in 2020.

Analyses were performed for base fields of 750 × 750 m. Depending on the analysis period, the number of observations could be different, which is due to the small number of visits and anonymisation of data.

Results

Overview of the results

The total number of unique visitors (monthly unique visitors) was 370,527 in 2019 and 429,592 in 2020. There was an increase of 59,065 visitors. Figure 2 shows that only in the period from April to June, the number of visitors to the *Sudety Zachodnie* was higher in 2019 than in 2020. This was the period of the first lockdown and the beginning of the easing of restrictions. A significant increase in the number of visitors was observed from July to October, that is, the period when the restrictions were reduced to a minimum.

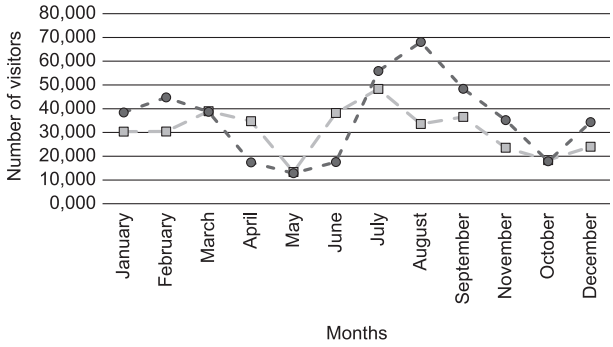

Fig. 2. Number of visitors.
Source: own elaboration.

Visitor profile

In both years, the majority of people visiting the *Sudety Zachodnie* area were women – 56.5% in 2019 and 55.2% in 2022 (a difference of 1.3%). The structure of visitors was dominated by people aged 30–44 years (36.9% [2019] and 37.7% [2020]). Those aged 20–29 and 45–49 accounted for approximately 25.5% in 2019 and 27.5% in 2020. Children and young people <19 years of age accounted for approximately 5.8% of visitors in both years. Older people >60 years old accounted for 6.0% of the visitor age structure in 2019 and 1.3% in 2020. A significant decrease was recorded for visitors who played sports, from 47.5% (2019) to 37.4% (2020).

Place of residence

In 2019, an average of 45.8% of visitors to the *Sudety Zachodnie* came from the Dolnośląskie Voivodeship (local visitors), 39.6% from other voivodeships in Poland (domestic visitors) and 14.6% from abroad (international visitors) (Fig. 3). The period of the pandemic caused a change in this structure. An increase in the number of local visitors by 13.6% (to 59.4%), a decrease in domestic visitors by 4.3% (35.3%) and a decrease in international visitors by 9.3% (to 5.3%) were found. For individual months, it should be noted that the structure of visitors by place of residence was similar from January to March. After the introduction of the first restrictions, lockdown and the first weeks of the easing of restrictions (April–June), there was a significant increase in the structure of local visitors (increase from about 45.4% to 87.1%), with a simultaneous decrease in domestic visitors (decrease from about 37.9% to 10.8%) and international visitors (decrease from about 16.7% to 2.1%). The period of easing restrictions brought an increase in the percentage of domestic visitors by approximately 8%. During the second lockdown (November 2020) and in the pre-Christmas period (December), the share of local visitors increased (increase from about 41.1% to 58.9%). Since the restrictions were introduced at the end of March 2020 and there was continuation of travel restrictions between countries, the percentage of international visitors had decreased to an average of 2.8%.

In the structure of local visitors (by counties of the Dolnośląskie Voivodeship), the most represented in both years were residents of counties where the study area is located or of neighbouring counties (Karkonoski [~8.1%], Lubański [~6.8%], Lwówecki [5.8%], Jelenia Góra [9.8%]), and inhabitants of large cities (Lubin County [14.5%], Wroclaw County [16.4%] and the city of Wrocław [18.5%]). It should be emphasised that during the first lockdown, residents of the county in which the study area is located and of the

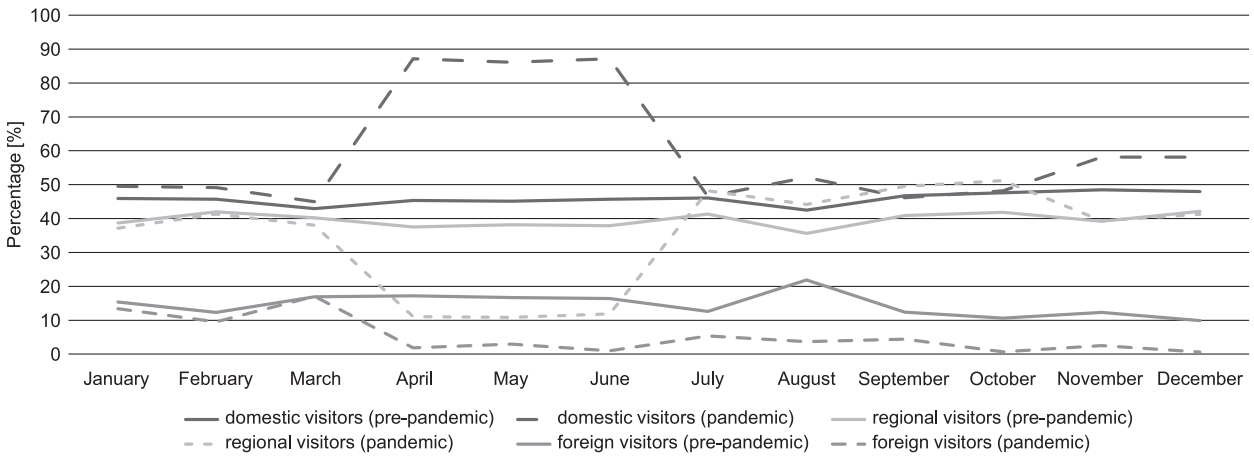

Fig. 3. Structure of visitors.
Source: own elaboration.

neighbouring counties accounted for a total of 61.3% of domestic tourists, with an annual average of approximately 30.5%. During the second lockdown, no such change occurred.

In terms of voivodeships, most tourists were located in the Dolnośląskie Voivodeship (local visitors), where the research area is located. In 2019, the share of tourists from this voivodeship was 53.5%, and in 2020, it was 57.2% (an increase by 4.7%). Residents of the voivodeships bordering the Dolnośląskie Voivodeship accounted for 12.2% (Wielkopolskie), 8.3% (Opolskie) and 5.1% (Lubuskie). Moreover, 6.5% were inhabitants of the Śląskie Voivodeship. During the first lockdown and the first phase of easing restrictions, the structure of visitors by voivodeship changed. In the April–June period, residents of the Dolnośląskie Voivodeship accounted for about 89.1% of all visitors, broken down by voivodeship. Thus, local tourism dominated.

The structure of international visitors was dominated by residents of the Czech Republic and Germany, that is, countries directly bordering the study area. The percentage share of these people in the structure of foreign tourists was about 35.7% and 24.5%, respectively, in the two years studied. After that, the study area was visited by citizens of Ukraine (about 10.1%) and Russia (about 8.2%).

The various stages of the pandemic and restrictions

During the first lockdown, the total number of visits to the 750 × 750 m base fields was 139,211 in 2019 and 119,405 in 2020 (a decrease of 14.2%) (Fig. 4). The statistical analysis showed that the number of visits significantly increased in 13 base fields (5% of all analysed fields) and significantly decreased in 61 fields (25%). The base fields where there was a significant decrease were located near *Szklarska Poręba* and on the tourist routes leading from the city to the national park. In 166 fields (103 fields with a decrease [43%] and 63 fields with an increase [27%]), the differences were not significant.

The period of ban on entering green areas and forests was characterised by a significant decrease in the number of visits to 111 base fields (56% of the analysed fields) and an increase in 12 (6%). Moreover, an insignificant decrease was recorded in 71 fields (36.5%) and an increase in three basic fields (1.5%). Fields with a significant fall were located again in the vicinity of *Szklarska Poręba* and also in the vicinity of *Świeradów-Zdrój* (north-western part) and *Jakuszyce* (south-western part). During this period, there was a decrease in visits by 33,038 (89,051 in 2019 and 56,013 in 2020 – a decrease of 37.1%).

A change in trend in the number of visits was observed during the selected period of easing of restrictions, when there was a significant increase in 87 base fields (33% of the base fields analysed) and a significant decrease in 84 (32%). An insignificant increase was observed in 64 basic fields (24%) and a decrease in 29 fields (11%). The total number of visits was 7,000 higher in 2020 than in 2019 (an increase of 2.75%). During this period, the clusters with a significant decrease and a significant increase stood out.

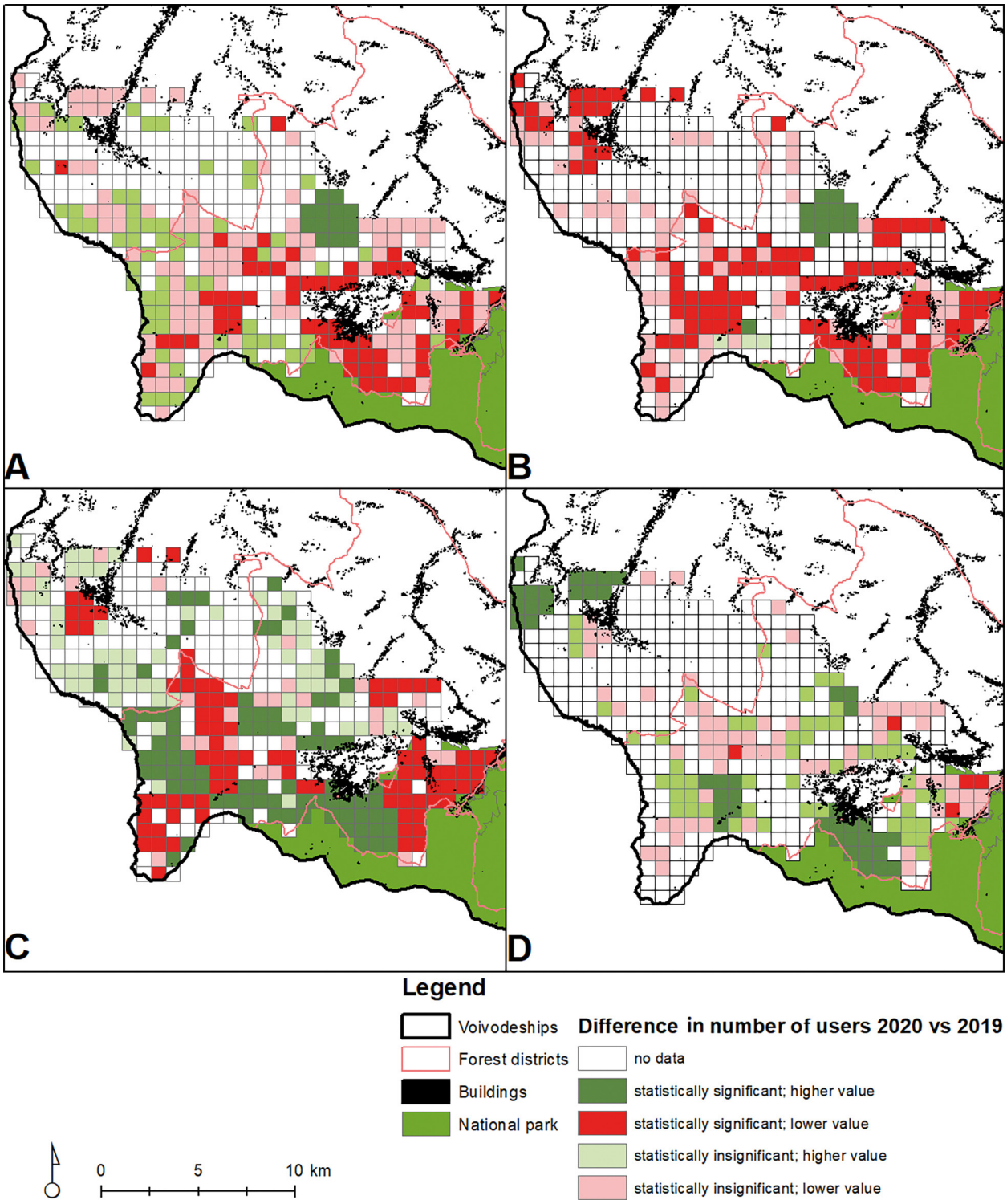

Fig. 4. Difference in the number of visitors in 2020 vs. 2019 in different pandemic periods: A – first lockdown, B – ban on entering green areas and forests, C – easing of the restrictions, D – second lockdown. Source: own elaboration.

Visits to base fields during the second lockdown increased by 38,033 compared to 2019 and totalled 238,015 (19% increase). An increase was recorded in 96 base fields, which represented 57% of the fields analysed (43 with a significant increase [26%], 53 with an insignificant increase [31%]) and a decrease in 71 fields (43%) (five with a significant decrease [3%]). A significant increase occurred in the base fields at *Świeradów*, *Jakuszyce* and *Szklarska Poręba*.

Discussion

The changing conditions resulting from the restrictions, as well as the different perceptions of the pandemic by society (from panic to negation [Kalinowski 2020]), meant that the period of the pandemic cannot be treated as homogeneous. The dynamics of the process of change during the pandemic was also emphasised in the work of Lewtak and Nitsch-Osuch (2021). The study used the division of 2020 according to the methodology proposed by Ciesielski et al. (2022). This division made it possible not only to compare the overall pandemic year 2020 against 2019 but also changes in the use of forest during individual periods of the pandemic. This is a different approach in relation to previous works that examined the impact of the pandemic on recreation in natural areas (Derks et al. 2020; Lopez et al. 2020).

The results presented show that, in the first year of the pandemic, there was an increase in the number of visitors to the forest areas. This result confirms the majority of works in the field. Geng et al. (2021) pointed out that there was a significant increase in the demand for rest in green areas. The authors used data from Google Mobility for their work. Derks et al. (2020), who used data from pyroelectric sensors, also pointed to an increase in the number of visitors to suburban forests in Germany. One of the factors driving this increase is proximity to home. As shown in the results of surveys conducted in the Czech Republic, the number of forest visitors in 2020 also increased compared to previous years (Jarský et al. 2022). Weinbrenner et al. (2021) emphasised that, during the lockdown, the frequency of forest visits and their durations increased. The authors described the role of forests during the pandemic by including the phrase 'The forest has become our new living room' in the title. As Grima et al. (2020) pointed out, the behaviour of society also changed, as people who previously did not use forests or used them sporadically now began to use forest areas. On the other hand, Astel-Burt and Feng (2021) emphasised that the demand for using green areas depended on material status. The increase in the number of visitors to forest areas was also influenced by the restrictions that led to the closure of many places where the public used to spend their leisure time (cinemas, theatres, museums and restaurants). This factor, leading to a lack of alternative recreational activities, was cited by Soga et al. (2021) as the main determinant of behaviour change. The increasing number of visits to forest areas has highlighted the important role of these areas in providing the public with a place to relax, which has a positive impact on health and well-being (Kleinschroth, Kowarik 2020). It should be emphasised that the type of activities performed in the forest has not changed, but the importance of non-productive functions of the forest has been emphasised in the public opinion (Derks et al. 2020). Pichlerová et al. (2021) pointed out that, given the increased interest in forest recreation, it was crucial to maintain and develop existing infrastructure to meet society's expectations. In addition, the authors emphasised that attention should be paid not only to protect existing ecosystems but also to create new natural areas. On the other hand, the increase of tourism in forest areas may affect recreational experiences. In extreme cases, too much traffic can lead to conflicts between different user groups (Bamwesigye et al. 2021).

Dividing the first year of the pandemic into various periods made it possible to examine how the use of the forest changed in each of them. The first two periods (the first lockdown and the ban on using green areas and forests) were characterised by a significant decrease in forest visits. This confirms the previous results using measurement sensors in the work of Ciesielski et al. (2022). The period of the first lockdown fell in spring, the time when Poles frequently spend time in forest areas according to Grzyb et al. (2021). It should be recalled that in the first phase of the pandemic, there was a great fear in Poland of the consequences of the COVID-19 infection. The slogan '#stay at home' was widely used, and most people adhered to the restrictions introduced. Therefore, the observed decline is not surprising. As shown in the survey conducted by the SWPS Research Centre (SWPS, 2020), during the initial phase of the pandemic, almost 90% of the population adhered to the guidelines. Over time, due to pandemic fatigue and a dismissive attitude, this percentage declined significantly to l<70% in December 2020 (SWPS 2020). The decline in the percentage of those complying with the restrictions may have influenced the increase in visitation to forest areas during the second lockdown.

During this phase of the pandemic, the number of positive COVID-19 tests in Poland increased significantly (during the first lockdown, there were about 1,000 positive tests per week; during the second lockdown, there were >160,000). Nevertheless, the mobility of the society in the forest areas increased compared to the year before the pandemic.

The selected research area is an attractive destination due to its natural values. This is one of the reasons that could explain the increase in the number of visitors to forest areas during the period of easing of the restrictions. An increase in the number of visitors to forest areas during the summer was also observed in the work of Geng et al. (2021) and Ciesielski et al. (2022). This could be due to the increasing importance of domestic tourism.

The use of base fields with a relatively high spatial resolution made it possible to identify locations where the number of visitors decreased or increased. During the first lockdown and the ban of forest areas, three locations experienced significant declines. These were places near the largest cities (points 2 and 3, Fig. 4) or places with a large concentration of tourist routes and recreational infrastructure (points 1 and 2, Fig. 4). As a result, the intensity and mobility of society decreased in the areas that were once the most used. During the second lockdown, the number of visits to these places increased significantly. This is probably related to the aforementioned decrease due to the fear of coronavirus infection.

The structure of visitors also changed during the pandemic. The first lockdown resulted in almost 90% of visitors living in the Dolnośląskie Voivodeship in the period from April to January, of which >60% lived in municipalities located in or near the study area. The restriction of mobility due to the ban on foreign travel or the required fulfilment of the test obligation caused the percentage of international visitors to drop to about 2%. Similar observations were made by Spenceley et al. (2021) and Venter et al. (2020) for the Oslo area and by Volanec et al. (2021) for parks in New Jersey. Kupfer et al. (2021), in their research on national parks in the United States, also found that as a result of restrictions, the number of visitors from out-of-state and distant states declined. However, the importance of local tourism increased.

A significant decline in the proportion of older people (>60 years of age) who chose to be active in forested areas is also worth noting. As the research of Chan (2022) shows, the decline in tourism activities of older people is mainly due to health factors.

Limitations and advantages of mobile phone data

Mobile phone data comprise the largest collection of data on mobility in society (Monz et al. 2019). Because it contains commercial data, it can be purchased for a fee. The acquisition cost depends on the area, temporal and spatial resolution, number of user profiles and resulting database queries by the data provider. Therefore, acquisition costs can be significant. From the perspective of forest managers, it is therefore important to properly match mobile data to the needs. To this end, it is necessary, among other things, to establish representative time periods for collecting detailed data and to properly define the areas of data collection (e.g. locations of recreation infrastructure facilities to verify their popularity). Optimising demand may make buying data cheaper than conducting surveys, for example (Jiang et al. 2017). In the context of the impact of the COVID-19 pandemic and the restricted use of forest, mobile phone data can be used to obtain detailed information about the spatial and temporal distribution of society. It is possible to analyse the different phases of the pandemic and compare their effects on society's behaviour (Yang et al. 2020). Importantly, the data are continuous, that is, they are collected for the entire area. This is an undeniable advantage over research using point methods of data collection, such as pyroelectric sensors (Ciesielski et al. 2022). Sensor data provide very accurate information, but require a well-developed deployment and analysis methodology (Rogowski 2020; Farías-Torbidoni et al. 2022). However, their use is most common in compact areas such as national parks (Rogowski 2019). In forest areas, where forest complexes vary in size, large distances exist between them, and it is difficult to define entrances and exits, the use of sensors is usually limited to selected areas. Mobile phone data can be used to determine the place of residents and user profiles with high accuracy. Forest

managers can thus obtain quantitative and qualitative information simultaneously. Similar data can be obtained with user-generated data, but the spatial and temporal scales of analyses are much smaller (Ghermandi, Sinclair 2019; Fox et al. 2020; Ciesielski, Stereńczak 2021; Grzyb et al. 2021). Moreover, these data are generated by a specific group of users, usually younger than the general public (Grzyb et al. 2021). However, the limitation of mobile phone data is that it is not possible to determine people's motivations for visiting forest areas (Rice, Pan 2021). Therefore, it seems that mobile phone data should be enriched with representative surveys to determine the needs and motivations of recipients and their feelings about forests. In terms of research, privacy policies are also important. The institutions sharing the data provide them with full anonymity and no personal information. However, it should be remembered that the individuals whose data are used in the research are usually unaware of it. This is because the privacy policies presented for acceptance by various portals, applications and mobile networks are very often accepted instinctively and without thinking. Then, the user data are given to the outside world while maintaining anonymity. During the COVID-19 pandemic, mobile data were successfully used for analyses of, e.g., the impact of restrictions on reducing the mobility of society (Levin et al. 2021).

Conclusions

From the results presented, it appears that the pandemic and the restrictions affected both the number of people visiting forest areas and the structure of visitors by place of residence. The analysis of the different periods of the pandemic and the restrictions showed that the pandemic cannot be treated as a whole. The behaviour of the society due to psychological factors and the restrictions introduced varied during different periods of the pandemic. Over the period of the first lockdown, there was a significant decrease in the number of visitors, but after more than half a year and the introduction of the second lockdown, the trend completely reversed. This could be a confirmation of the special role of forests in providing society with places of rest. The mobile phone data allowed a thorough analysis of changes in the spatio-temporal distribution of activities in forest areas. This type of data should be used to manage forest areas, such as in the context of making forests available to the public. Access to forests was of particular significance during the pandemic, but it is also important to conduct research to determine the long-term effects of the pandemic on the role of forests in meeting the needs of society.

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