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Determining the Range of Influence of Tourist Trails Users on Naturally Valuable Areas: A Proposal of a Method and a Practical Example

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Abstract:

Purpose: *The aim of the article is to present the proprietary methodology for determining the area range of anthropopressure to areas of natural value located along tourist trails and to the entire area where those trails are located.*
Design/Methodology/Approach: *A method of critical analysis of information obtained from various dispersed sources was used to determine the widths of the buffers of the impact of tourists using various types of tourist trails on the environment. Current geodetic and cartographic studies as well as geoportals and thematic websites available on the Internet were used to properly define the course of tourist routes. Spatial analyzes were performed using the ArcGIS software environment.*
Findings: *The results of the research confirm that the proposed simple, cheap and effective methodology allows to take into account many elements of nature and to consider the range of pressure on valuable natural areas as a whole or only on their selected element. It also allows to choose the form of tourist activities in the analyzed area.*
Practical Implications: *The proposed method can be helpful in the management of protected areas, including, for example, the assessment of the tourist capacity of the area and the development of opinions on the creation of new and updating or correction of the existing tourist trails.*
Originality/Value: *Authors presented an algorithm of the most important activities and types of spatial analyzes necessary to identify the extent of the impact of people using various types of tourist trails on naturally valuable areas*

Keywords: *Environment protection, management of naturally valuable areas, spatial analysis and planning, tourism.*

JEL codes: *Q01, Q26, Q56, Q57, R10, R14, Z19,*

Paper Type: *Research Paper / Case study.*

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1. Introduction

Looking at the trends of recent years, it can be concluded that one of the most important directions of socio-economic development of rural areas is the development of tourism. The most important elements of the natural environment that determine the tourist attractiveness of a given area are surface waters, flora and relief. This is due to the fact that they can be used to create various types of tourism products (Torquati *et al.,* 2017; Fernández Martínez *et al.,* 2020). Observations on the forms of recreation chosen by people or possible to be implemented during the COVID-19 pandemic suggests that the so-called nature tourism will also become more and more popular after its completion. For this reason, the development of the tourism industry should take into account the so-called responsible tourism. Planning and management requires information on spatial and social aspects of visitor behavior to balance the use of natural resources and the impact of humans on protected species and habitats / areas (Źróbek *et al.,* 2012; Korpilo *et al.,* 2018; Muñoz *et al.,* 2019; Źróbek *et al.,* 2020). It should also be noted that the increased interest of tourists in spending free time in the proteced areas may result in the development of agritourism in nearby villages and the promotion of cultural heritage, and thus the renovation of old houses and habitats (Siniak *et al.,* 2019; Kutut *et al.,* 2021).

In geographical literature, tourist trails are the domain of the so-called linear recreational penetration systems. The geoecological approach to this issue assumes that the tourist trail is a system in which the following interact with each other: a tourist moving along the penetration route (axis of the system) and the components of the tourism space within his sight (values of the natural and anthropogenic environment and elements of tourism development). The main role of tourist trails is to enable the penetration of the environment for tourist and recreational purposes, and thus, above all, to provide sightseeing values, such as: watercourses, reservoirs, landform forms, plant communities, landscapes, folklore, cultural monuments and art, historical mementos, etc. Ecological functions, on the other hand, are oriented mainly at limiting tourist traffic and preventing undesirable distraction of tourists by targeting recreational penetration. Tourist trails are marked in order to make it easier for tourists to reach the most interesting places in the region. Land rtrails use roads and paths running in the field, while water routes run through navigable waters and watercourses (Godtman *et al.,* 2017; 2019).

In Poland, in the area of national parks and nature reserves, these are usually the only acceptable routes that tourists can travel on without a special permit (Szczęsna and Wojtanowicz, 2014). However, frequent observation of traces of the presence of tourists outside the designated routes supports a hypothesis regarding the strong pressure of tourists around the designated routes. This is so, for example, because tourists, by avoiding congestion, obstacles, ground damage, mud or avoiding each other, tread new paths (Ballantyne and Pickering, 2015; D'Antonio and Monz, 2016). It should be remembered that the excessive number of tourists using the

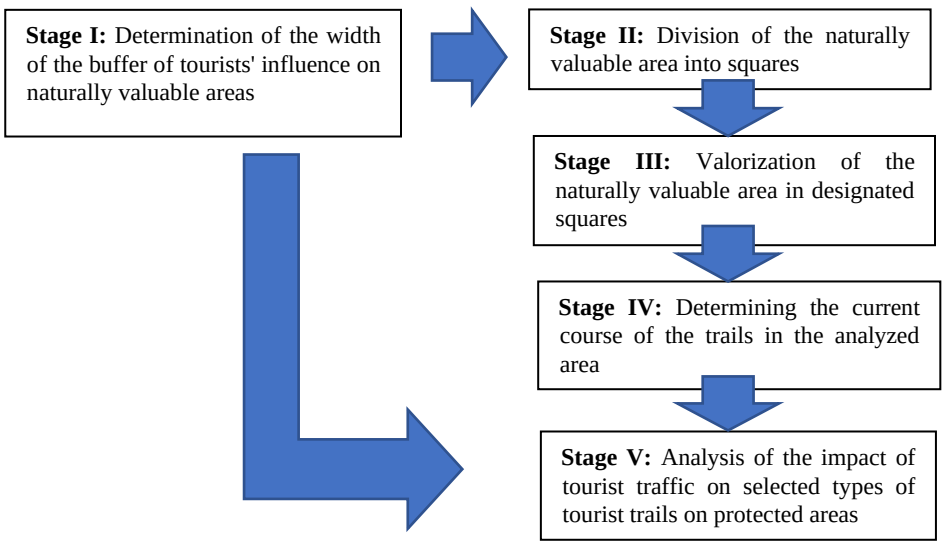
designated routes is the cause of environmental degradation (Dynowski *et al.*, 2019; Senetra *et al.*, 2020; Oleśniweicz *et al.*, 2020).

The paper presents a proprietary method that allows to determine the extent of anthropopression to valuable natural areas located both closest to the tourist trails and to the entire area where these routes are located. The presented analyzes and research results constitute a good methodological basis for other studies on anthropopressure in naturally valuable areas, eg. the impact on market value of such areas (Źróbek, 2002) . The proposed method can be used, among others in analyzes leading to the assessment of tourist absorption capacity and support the management of protected areas. The results of the implementation of all proposed activities, as well as those obtained at individual stages of the presented procedure, may constitute the basis for the development of partial opinions, designing new ones, updating or correcting the course of existing tourist routes.

2. Determination of the Impact Range of Tourist Traffic on Selected Types of Tourist Trails - Description of the Proposed Method

In order to achieve the main goal of the research - to define the scope of anthropopressure, the proposed methodology distinguishes intermediate, partial goals marked in Figure 1 as stages. The algorithm for the implementation of the method consists of 5 stages, the sequence and scope of which are not accidental - they result from the need to have materials and information to undertake the next planned activities.

Figure 1. *Scheme of methodology for determining the range of impact of tourist trail users on naturally valuable areas*



Source: *Own study.*

First of all, the widths of the buffers of the impact of tourists using various types of tourist trails on the environment (stage I of the procedure) should be determined. For this purpose, it is recommended to collect information from many dispersed sources (e.g., people directly involved in the management of protected areas, tourist guides, professional literature, including studies on tourism and recreational valorization, people who practice tourism in areas of natural value, questionnaires, etc.). Due to the specificity of the problem and the lack of "official" indicators, it is also advisable to have one's own experience acquired in conducting environmental research.

The subsequent stages of the procedure of the proposed method require many spatial analyzes to be carried out in the studied area. In the presented method, an important issue is to determine the natural value of the areas subject to anthropopressure. For this purpose, in stage II, it is proposed to divide the area into smaller research fields. For this type of analysis, it will be appropriate to use a square grid covering the entire study area, with the length of the square side corresponding to the largest width of the tourist impact buffer determined for a given area.

Another task (stage III) is to determine the natural value of the areas subject to anthropopressure at the ecosystem and landscape level. For this purpose, each of the designated squares should be analyzed in terms of the forms of nature protection existing in its area. Each form of nature protection is assigned 1 point. Then the number of points in the individual squares is summed up and the final value for each square is obtained.

To achieve the main goal, it is important to have current and clearly presented information on the location of the trails. For the proper determination of the course of tourist trails (stage IV), it is recommended to use current geodetic and cartographic studies (e.g. owned by people and / or institutions managing a naturally valuable area) and from publicly available sources on the Internet (e.g., geoportals and thematic websites). It is worth verifying the data in terms of topology, using a topographic base and an orthophotomap.

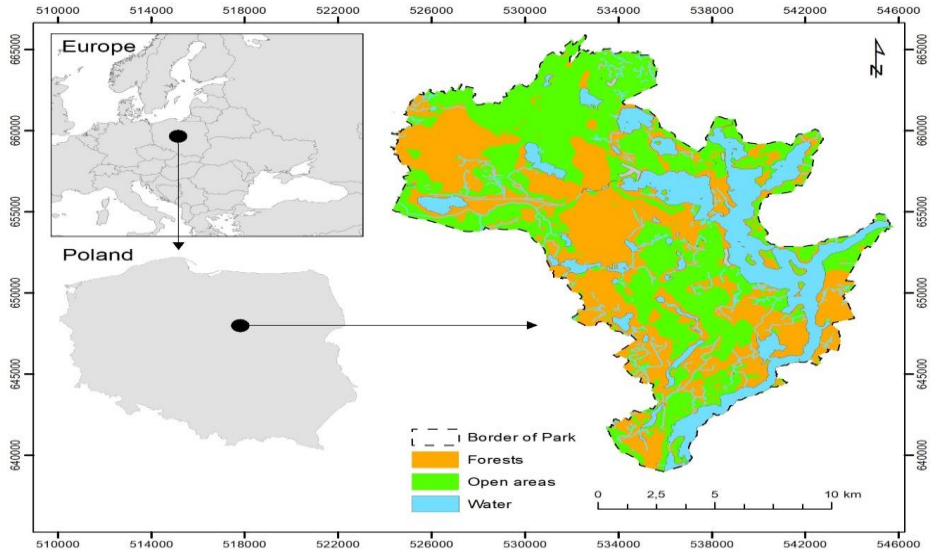
The results of the work carried out in the previous stages constitute the necessary material for the implementation of the most important - stage V of the procedure of the proposed method - for the analysis of the impact range of tourists using selected types of trails in the designated buffer. This analysis requires, first of all, adding an appropriate buffer width to the boundaries of the existing trail and intersection of the resulting surface layer with a grid of squares of the natural valorization of the protected area. Then, fragments of the selected square grid, with the same natural value, should be put together and the most valuable surfaces, and at the same time subject to the greatest tourist pressure, should be analyzed in detail. If it is found that too large percentage of the most valuable natural areas (located both along the routes and in the entire studied area) are within the range of the impact buffers, it is necessary to correct the course of the trails so as to move them away from the most naturally sensitive parts of the protected area. It is also advisable to analyze the

combined extent of the impact of all types of trails running through the area. This will make it possible to know the scale of the pressure on the entire investigated protected area. Obtaining such information is necessary when the manager of the protected area plans further development of tourist infrastructure. It is very helpful in decisions related to the channeling of tourist traffic, i.e., acceptance of the location of subsequent tourist trails and places of tourist concentration.

3. Application of the method - Case study

The Landscape Park of the Iława Lakeland (hereafter referred to briefly Park) is one of the most attractive tourist parks in north-eastern Poland (Figure 2). The area of the Park covers approx. 25 279 ha, of which more than half are forests, and the second is water (Dąbrowski *et al.,* 1999). The boundaries of the Park include over 40 lakes, including Jeziorak Duży, which is the longest water reservoir in Poland and the fifth largest (Dobies and Plantner, 1998). 66 plant communities preserved in natural state are distinguished here (Jutrzenka-Trzebiatowski *et al.,* 1997). The variability of plant communities greatly enriches the biodiversity of the co-existing fauna. Such habitats become progressively rarer in Poland and Europe.In order to verify the proposed methodology for determining the extent of anthropogenic pressure on naturally valuable areas, three types of trails were taken into account, walking, baiking and kayaking. Detailed field research covered only selected areas, selecting them so that they were examples of areas with different nature protection regimes, and at the same time - that the trails of each of the three analyzed types run within them.

Figure 2. *Location of the research area*



Source: *Own study.*

3.1 Determining the Width of Buffers of Tourists' Influence on the Environment

In order to determine the width of the buffers of the impact of tourists from various types of tourist trails located in the Park (stage I) on the surroundings, various dispersed sources of information were used. Information was obtained, i.a., from the park management; interviews with park rangers and tourist guides were held. In addition, we were supported by our own knowledge and experience gained during many years of inventory research of aquatic and terrestrial ecosystems in valuable natural areas.

One of the important sources of obtaining information were also the responses of people to whom anonymous questionnaire inquiries were sent. These studies were conducted in the period January-March 2021. The surveys were made and conducted using the Google Workspace software. Out of 325 questionnaires sent, 200 responses were obtained. In the form, questions were asked about the ranges of distances at which the respondents move away from various types of trails (presented later in the paper as the type of trail - "Me") and the range of distances to which respondents, other users of different types of trails are moving away (presented later in the paper as a type of trail - "Others").

The survey results were subjected to descriptive statistical analyzes using STATISTICA version 13.3 with the addition of STATISTICA for marketing and market analyzes (TIBCO Software Inc.). In order to be able to perform statistical analyzes, each answer to the question about moving away from the designated pathways was assigned an appropriate value of rank (Table 1). The following measures of location were used to describe the variables: median, mode, and lower and upper quartiles (Table 2).

On the basis of the analyzed survey responses, approximate ranges of buffers for the impact of tourists moving along designated tourist trails were determined. The final buffer width, adopted for the next part of the analyzes, was determined using the information obtained from all the previously presented sources of information. For further analysis the following buffers were selected, 100 m for walking and biking trails and 50 m for kayaking trails. However, due to the impossibility of channeling tourist traffic on water reservoirs, it was assumed that the potential range of kayakers' influence covers the entire water reservoir through which the trail runs. The walking trails include nature and educational paths.

Table 1. *Individual value of rank assigned to specific distance ranges chosen by the respondents.*

Value of rank	Distance range
1	less than 10 m
2	10-50 m
3	over 50 to100 m

4	over 100 to200 m
5	over 200 m

Source: *Own study.*

Table 2. *The descriptive statistics of individual types of trails. For the median and the mode, the value of rank and distance range are shown*

	% valid obsvn.	Median	Mode	Frequency of Mode	Min.	Max.	Lower Quartile	Upper Quartile
WALKING trail-Me	100	2 (10-50 m)	1 (less than 10 m)	93	1	5	1	2
WALKING trail-Others	100	3 (50-100 m)	3 (50-100 m)	62	1	5	1	4
BIKING trail-Me	100	2 (10-50 m)	2 (10-50 m)	64	1	5	1	3
BIKING trail-Others	100	3 (50-100 m)	3 (50-100 m)	48	1	5	2	4
KAYAKING trail-Me	100	3 (50-100 m)	2 (10-50 m)	92	2	5	2	5
KAYAKING trail-Others	100	2 (10-50 m)	2 (10-50 m)	92	1	5	2	3

Source: *Own study.*

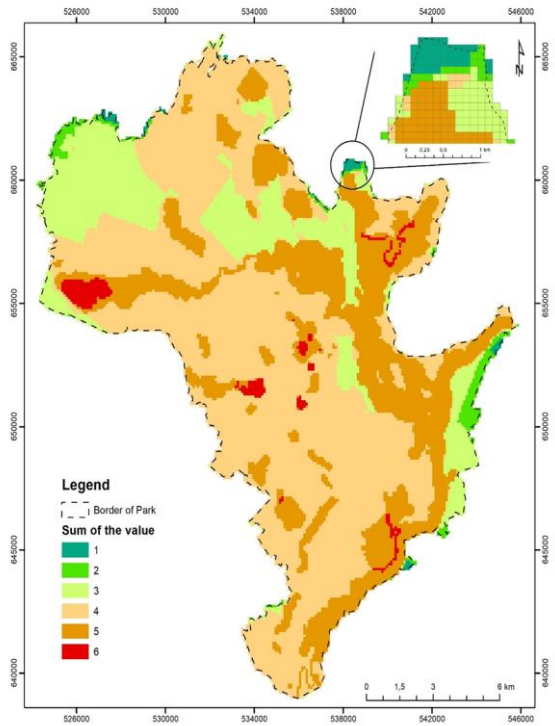
3.2 Spatial Analysis

ArcGIS 10.7 (ESRI) software was used to perform spatial analyzes performed in the subsequent stages of the procedure of the proposed method. In order to valorize the nature (stage II), the area of the analyzed Park was covered with a grid of squares with a side of 100 m (the largest buffer of potential impact of tourists designated for a given area). A total of 26,241 squares were obtained.

Then, each square was analyzed in terms of the existing form of nature protection: landscape park (1 point), Natura 2000 areas (1 point), nature reserves (1 point), planned nature reserves (1 point), ecological corridors (1 point), ecological lands (1 point), lakes (1 point), which were considered particularly valuable and subject to very strong anthropopressure. On this basis, the value for each of the analyzed squares was determined (stage III, Figure 3). After valorization of the naturally valuable areas in the designated squares, it was found that the maximum obtained value was 6. Such natural value was marked in 435 squares, which is about 2% of the Park area. A similar area was occupied by the areas with the lowest value (2 and 1 point). In approximately 17% of the analyzed area (4354 squares), three forms of nature protection were found (value 3). The value of the value equal to 5 was found in 6753 squares (approx. 26% of the Park area). The largest area, 14,144 ha (approx. 54% of the Park's area), was occupied by squares of value 4.

Geospatial studies obtained from Park employees as well as geoportals and thematic websites available on the Internet were used to determine the current course of tourist trails (stage IV). The data on the location of the trails were verified topologically (the trails were brought closer to the existing roads and watercourses), using the topographic background and orthophotomap.

Figure 3. *The distribution of the most valuable squares within the Landscape Park of the Iława Lakeland in a designated buffers*



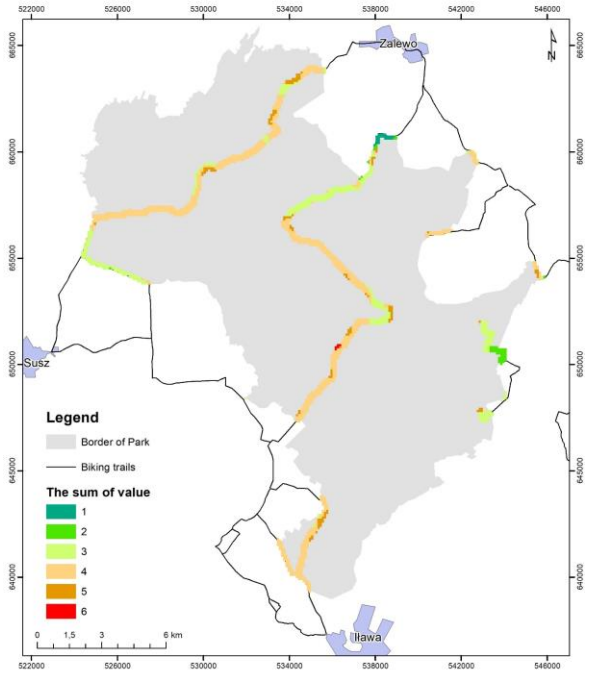
Source: *Own study.*

To analyze the impact range of tourists using selected types of trails, buffers of appropriate width were added to the linear layers prepared in the ArcGIS program (stage V). In the sections of the kayaking trails leading through the lakes, the border of the shoreline of the reservoir was considered a buffer. The rationale for this procedure is the lack of marking of kayaking trails on the surface of the lakes and the strong penetration of the reservoirs by kayakers, often dictated by weather conditions.

About 7% of the Park's area was located within 100 m of the buffer from all walking trails (Figure 4). The most valuable fragments with the value 6 and 5, which may be subject to the pressure of pedestrians in the designated buffer, were recorded in 63 and 382 squares, respectively. The largest number of squares (1,255) potentially

exposed to tourist dispersion in the areas adjacent to the walking trails are areas with the value of 4 (approx. 65%). Fragments of Park, within the range of the impact of walking trails, covered by three forms of protection, occupy an area of 206 squares. The areas with the lowest values, i.e., 2 and 1, can be penetrated on the area of 20 and 7 squares respectively. Moving along this type of trail, tourists can potentially influence approx. 14% of the area of all the most valuable parts (value of 6) of the Park. The participation of the area of a given value in the designated buffer and in the entire area of the Park is presented in Table 3.

Figure 4. *The range of impact of walking trails in the Landscape Park of the Iława Lakeland in a designated buffer*



Source: *Own study.*

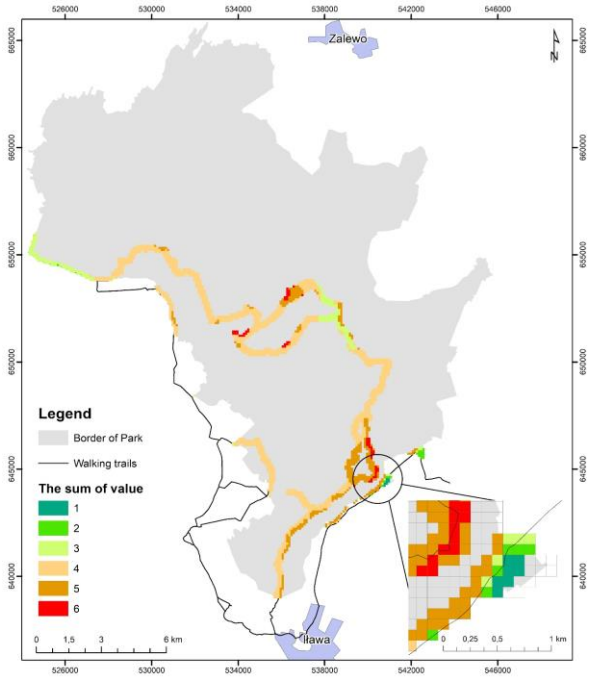
Table 3. *The range of impact of tourists using walking trails on naturally valuable areas located within the designated buffer and within the entire Park*

Value	Participation of the area of a given value in the designated buffer (in %)	Participation of the area of a given value in the area of the Park (in %)
1	0.4	6.3
2	1.0	4.5
3	10.6	4.7
4	64.9	8.9
5	19.8	5.7
6	3.3	14.5

Source: *Own study.*

Biking trails, together with a 100 m buffer, covered 6% of the Park's area (Figure 5). The most valuable areas, with values 6 and 5, which may be subject to the pressure of biking tourists in the designated buffer, are found in 5 and 131 squares, respectively. The areas whose natural value has been assessed at 4, in the areas adjacent to biking trails, constitute the largest area of potential dispersion, as much as 1027 squares. The area of more than twice as small, i.e. 467 squares, is covered by three forms of protection. The lowest value (value 2 and 1) was found in 52 and 24 squares potentially penetrated by biking tourists.

Figure 5. *The range of impact of biking trails in the Iława Lakeland Landscape Park in a designated buffer*



Source: *Own study.*

When using this type of trail, dispersion is observed on only 1% of the most valuable (value 6) areas of the Park. The participation of the area of a given value in the designated buffer and in the entire area of the Park is presented in Table 4.

Table 4. *The range of impact of tourists using biking trails on naturally valuable areas located within the designated buffer and within the entire Park*

Value	Participation of the area of a given value in the designated buffer (in %)	Participation of the area of a given value in the area of the Park (in %)
1	1.4	21.4
2	3.0	11.7
3	27.4	10.7
4	60.2	7.3

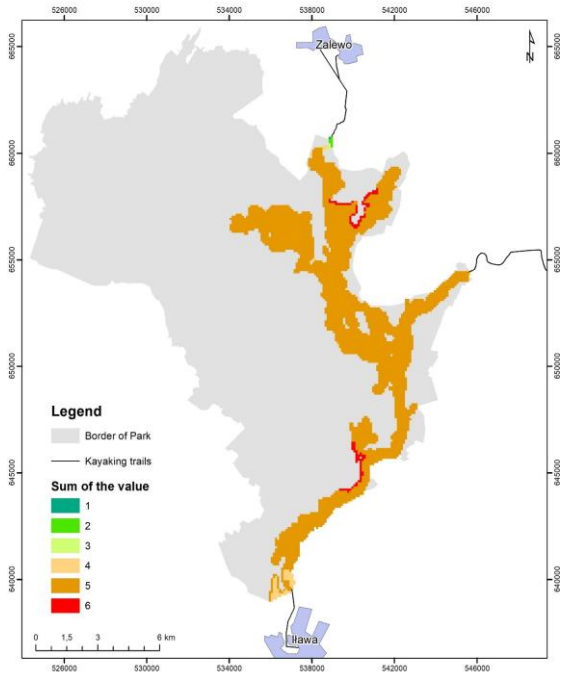
5	7.7	1.9
6	0.3	1.1

Source: *Own study.*

The impact of tourists, in the case of kayaking trails, concerns 16.6% of the Park area (Figure 6). This type of trails includes a 50 m wide buffer and the area of lakes through which they are marked out. The largest areas under the pressure of tourists are those of the highest value (5 and 6). In the case of the value 6, the penetration by kayakers may concern 112 squares, while in the case of the value 5 - 4,134 squares. Areas of lower value (4) are subject to pressure on the area of 89 squares, which is less than 1% of the area of this value in the Park.

The impact on the areas with the lowest values - 3, 2 and 1 is negligible as it concerns only 6, 7 and 1 square, respectively. Kayaking trails facilitate dispersion on approximately 26% of the most valuable areas (value 6) of the Park area. The participation of the area of a given value in the designated buffer and in the entire area of the Park is presented in Table 5.

Figure 6. *The range of impact of kayaking trails in the Landscape Park of the Iława Lakeland in a designated buffer*



Source: *Own study.*

Table 5. *The range of impact of tourists using kayaking trails on naturally valuable areas located within the designated buffer and within the entire Park*

Value	Participation of the area of a given value in the designated buffer (in %)	Participation of the area of a given value in the area of the Park (in %)
1	0	0.9
2	0.2	1.6
3	0.1	0.1
4	2.1	0.6
5	95	61.2
6	2.6	25.7

Source: *Own study.*

When analyzing all types of trails together (Table 6), it was found that the largest areas subject to anthropopressure are valuable parts of the Park, with the value 5. This applies to almost 17% of the area of the Park and over 65% of the area of this value. The smallest areas (less than 1% in total) where tourists penetrate are fragments of the area covered by one and two forms of nature protection (value 1 and 2). The total number of squares subjected to dispersion is 7,453, which is approximately 28% of the Park's area.

Table 6. *The range of impact of tourists using all types of trails on areas of natural value within the boundaries of the designated buffer and within the entire Park*

Value	Total number of squares (areas) located in designated buffers	Participation of the area of a given value in the area of the Park(in %)	Participation of the area of a given value in all designated buffers (in%)
1	31	0.1	27.7
2	75	0.3	16.9
3	523	2.0	12.0
4	2250	8.6	15.9
5	4429	16.9	65.6
6	145	0.6	33.3

Source: *Own study.*

4. Discussion

It is commonly believed that walking and hiking are one of the most popular leisure activities in the world (Walker and Shafer, 2011) and, at the same time, the greatest threat to adjacent areas (Kiszka, 2016). The trails lead to habitat fragmentation and limit the proper reproduction and development of animals and plants (Gutzwiller *et al.*, 2017; Pauwels *et al.*, 2020). However, the biggest problem is the process of treading the vegetation (Kolasińska *et al.*, 2015) within the trail surface and in its immediate vicinity, where there is a significant decrease in the density of grass covers, and ultimately to its complete disappearance (Kycko *et al.*, 2012). All this causes changes in the species composition of ecosystems (Ballantyne and Pickering,

2015), and the disappearance of species that are very valuable and characteristic of a given area. Forest fragmentation has a very negative impact on many bird species and larger predatory mammals. Tourist trails cross the paths of animal migration, and limit their living space and the number of convenient refuges. Tourists often scare and disturb forest animals, and increased car traffic increases the number of incidents in which animals are injured (Ferrani *et al.,* 2008).

Although bikinig is considered a low environmental impact activity, it can have negative environmental effects. This is due to the fact that biking causes increased compaction and abrasion of the ground from the trail surface compared to walikng/hiking (Martin *et al.,* 2018). An example of the negative effects of biking on vegetation is, for example, diaspora disease and thus the change in plant distribution; reducing the richness of vegetation species near biking trails due to soil disturbance and replacing sensitive vegetation species with tolerant species (Weiss et al., 2016; Stavi and Yizhaq, 2020).

World literature shows that outdoor recreational activities related to the aquatic environment enjoy a steady increase in interest, and kayaking dominates among them (Doukuli, 2013; Folgado-Fernández *et al.,* 2019). The wide negative impact of this form of recreation may be caused by the difficulty in sewing tourist traffic within water reservoirs. It should be emphasized that a single (incidental) dispersion on various sections of the trails causes greater environmental damage than the intensive use of areas with a limited area (Twardock *et al.,* 2010). Although the greatest pressure on water ecosystems is exercised by motorboating sports, also kayaing and sailing tourism often scare water-marsh birds. The result of such disturbances may be, as in the case of vegetation, a change in the areas of occurrence or the appearance of alien species, changes in the population size (Doukuli, 2013; Folgado-Fernández *et al.,* 2019).

Therefore, for over a dozen years there has been an increase in interest in research on the impact of various forms of tourism on widely understood wildlands among scientists and managers of naturally valuable areas. The literature review on this subject shows that the authors put the main emphasis on the analysis of the strength of tourist pressure expressed by the density of tourists and / or the number of people departing from the designated routes. However, these studies most often concern individual sites or areas that are small relative to the size of protected areas (Gutzwiller *et al.,* 2017). Moreover, the ecological impact analysis of tourist traffic most often concerns only selected groups of organisms and rarely refers to the ecosystem as a whole (Weiss *et al.,* 2016; Pauwels *et al.,* 2017; 2020). Contrary to the research methods proposed by other authors (D'Antonio and Monz, 2016; Pauwels *et al.,* 2020; Sisneros-Kidd *et al.,* 2021), it is also not required to purchase GPS receivers and deliver them directly to tourists.

5. Conclusions

1. The novelty of this manuscript is a proposal of a simple, cheap and effective methodology for assessing the spatial range of the impact of people departing from designated tourist routes, and thus to determine the extent of pressure on naturally valuable areas. The methodology proposed in the article is universal. Depending on the adopted valorization criterion, it allows taking into account many elements of nature and considering the range of pressure on naturally valuable areas as a whole or only on a selected element (type of ecosystem, group of organisms, etc.). It is also possible to choose the type / form of tourism to be practiced in the analyzed area.

2. In order to effectively manage protected areas, relevant entities should make wider use of IT tools and information systems facilitating the performance of many, often specialized, spatial analyzes. In the absence of dedicated GIS for protected areas, they should be created, e.g. based on information published in various distributed data sources, e.g. existing geoportals.

3. It is recommended that all plans for new tourist infrastructure in protected areas be consulted with the manager of such area. Planning documentation should include the characteristics of the impact range of the planned elements not only in relation to the designated buffer area, but should cover the entire protected area.

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