

## VARIANT DESIGNING OF EDUCATIONAL FOREST NATURE PATHWAYS BY USING GIS

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**Abstract.** The objective of this paper was to test in practical conditions possibilities of the application of GIS to design multi-variant educational pathways in the forest. An attempt was also made to develop a system of management of spatial information which makes it possible to design different alternatives of pathways in a specific forest complex. Nearly every fragment of the forest can be used to create educational paths. Usually, areas characterised by a considerable variability, situated in regions easily accessible for people are selected for such purposes. In the case of a strongly diverse area, the creation of multi-variant paths may be an ideal solution by providing different routes for persons of different ages and levels of education. There can also be theme alternatives presenting different problems or variants intended for selected ways of movement. GIS is very useful when designing many variants of educational pathways in one area. This system facilitates data collection at the phase of field inventory and allows designing many different alternative routes, as well as managing them in the course of their utilization.

**Key words:** variant designing, forest pathways, recreation, education, GIS

### INTRODUCTION

Nature education of the general public is becoming increasingly important. It is generally accepted that the best didactic effects are achieved performing different tasks directly in contact with nature. Forest environment provides an excellent place for carrying out the educational process and one of the more important methods which can be employed to conduct the teaching process is the use of educational nature pathways. It is a form of forest education which is enjoying an increasingly growing interest of the general public which fulfils simultaneously two functions: educational and recreational [Grzywacz 2000, Kapuściński 2003].

In practice, nearly every fragment of the forest can be utilized to create educational paths; nevertheless, usually, areas characterised by a considerable variability, situated in regions easily accessible to people are selected for such purposes. Greater diversity

makes it possible to show many aspects of the presented phenomenon or problem, while accessibility is a key factor influencing popularity of a given place [Chrzanowski 2004]. In the case of a strongly diverse area, the creation of multi-variant paths may be an ideal solution by providing different routes for persons of different ages and levels of education. Moreover, there can also be theme alternatives presenting different problems or variants intended for selected ways of movement, e.g. on foot, by bicycles, wheelchairs etc. The mapped out routes should: fulfil their educational function(s), be as attractive as possible and, at the same time, minimize the negative human impact on the environment.

A good example of a place exceptionally suitable for establishing educational pathways is the Zwierzyniec Forest situated in the direct neighbourhood of a town and lakes. It is a forest which, originally, was a manor park. It is characterised by a high variability, has old stands consisting of many tree species and interesting places of historical interest.

Geographic Information System (GIS) is very useful when designing many variants of educational pathways in one area [Węgiel et al. 2005]. This system facilitates data collection at the phase of field inventory and allows designing many different alternative routes, as well as managing them in the course of their utilization.

The objective of this research project was to test in practical conditions possibilities of the application of GIS to design multi-variant educational pathways in the forest. An attempt was also made to develop a system of management of spatial information which makes it possible to design different alternatives of pathways in a specific forest complex.

## STUDY AREA

The object of the research was the Zwierzyniec Forest, a former manor park situated in the Złotów Forest District (northern Poland). The forest is located in the direct neighbourhood of the town of Złotów and two lakes: Zalewskie and Złotowskie. The area is considerably diversified with a dense system of roads and paths, as well as many places attractive for tourists. The forest was designated by the local forest district for recreational purposes and it is there that the tourist traffic is to be focused.

The entire area of the present Zwierzyniec Forest was purchased in 1820 by Frederic Wilhelm III Hohenzollern. At the time, the task of developing the park was given to his chief gardener – Peter Joseph Lenne who was one of the most outstanding creators of gardens and parks in Europe, with the Sanssouci in Potsdam and the Tiergarten in Berlin among his best known achievements. In Zwierzyniec, Lenne focused, primarily, on the incorporation of the manor and its farming facilities into the surroundings. In 1876, the then owner of Złotów, Prince Charles Hohenzollern presented the area to the town and the Zwierzyniec Park became a place of foot and bicycle outings, festivities, parties and exhibitions. With time, the entire area ran wild and underwent a considerable damage. Grazing cows and pigs were among the worst wrongdoers. In recent years, the area has been reinstated as a forest area and, at the present time, is under the administration of the Złotów Forest District. Plans are underway to restore it back to its original design.

The Zwierzyniec Forest occupies the area of approximately 90 ha. Trees found there are 100 to 190 years of age. The dominant tree species are beech and oak but pine, fir and spruce are also numerous. Moreover, there are also many other tree species, both native, as well as foreign, which are remnants of the former manor park.

## METHODS

The performed investigations began with a detailed inventory of the Zwierzyniec Forest. The entire forest area was carefully examined in search of points and places which could be treated as stopping places for the planned paths. In addition, various types of maps, tourist guides as well as natural and historic books were studied to establish educational spots. Last but not least, interviews were arranged with the local people, mainly foresters, to supplement the collected data. All collected information was verified in the forest and the selected places were marked off on maps and their comprehensive descriptions were prepared. Courses of all the existing roads and paths were also marked.

In the next stage, classification of all educational spots from the point of view of their attractiveness was carried out. Each point was assigned one of three levels of attractiveness: high, moderate or low. A similar classification was conducted for roads and paths using the same three-scale level of assessment (Fig. 1). Degrees of attractiveness were determined subjectively taking into consideration aesthetic impressions, land contour, landscape value and touristic attractiveness of the selected places and pathways.

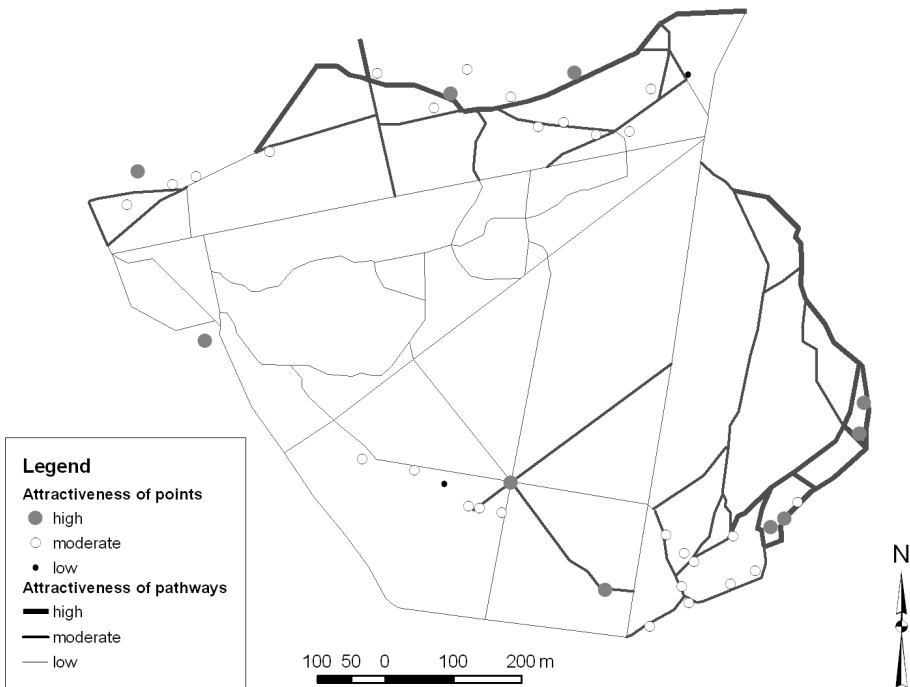


Fig. 1. Inventoried educational points and pathways and their division into three levels of attractiveness in Złotów Forest

Rys. 1. Zinwentaryzowane punkty edukacyjne i drogi z podziałem na trzy stopnie atrakcyjności

Bearing in mind ways of transport, all roads were allocated to one of the following four categories: 1) accessible to cars, 2) accessible to wheelchairs, 3) accessible to bicycles and 4) accessible to pedestrians. Naturally, roads accessible to cars were also available to wheelchairs, bicycles and pedestrians, roads for wheelchairs were also accessible to bicycles and pedestrians and roads for bicycles were also accessible to pedestrians, while roads for pedestrians were not accessible to any other vehicles (Fig. 2).

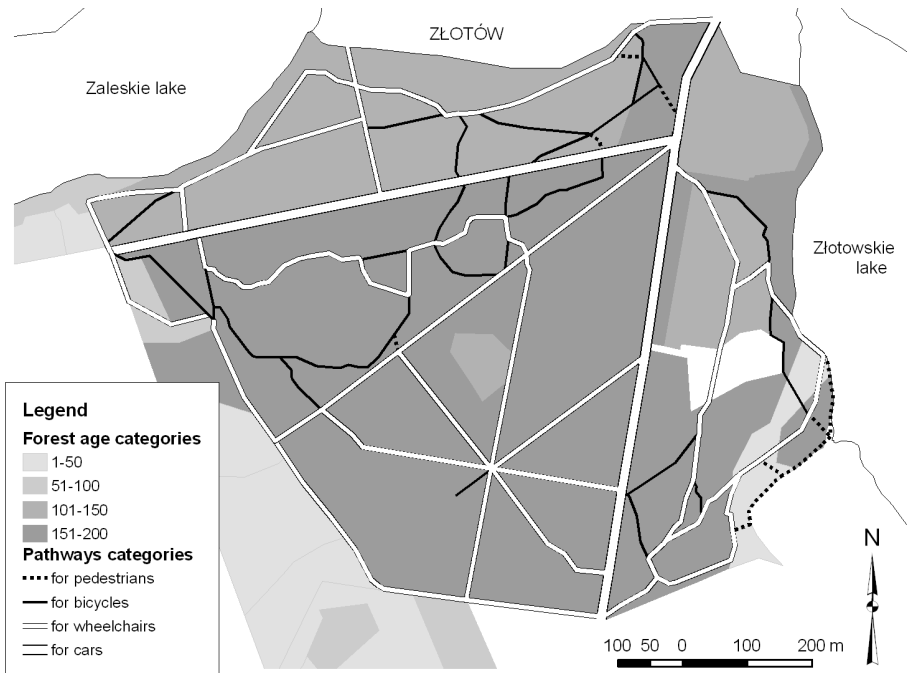


Fig. 2. Pathways categories: 1) accessible for cars, 2) accessible for wheelchairs, 3) accessible for bicycles, 4) accessible for pedestrians and four forest categories of age  
 Rys. 2. Kategorie dróg: 1) dostępne dla samochodów, 2) dostępne dla wózków inwalidzkich, 3) dostępne dla rowerów, 4) dostępne dla pieszych oraz cztery kategorie lasów o różnym wieku

Each educational point was assigned to one or more of the following eight subject categories: K1 – forest, K2 – plants, K3 – animals, K4 – geomorphology, K5 – water, K6 – seasonal changes, K7 – historical places and K8 – other interesting things. The determination of appropriate categories allowed the creation of theme pathways later on during successive stages of the study.

Once the field work had been completed, the authors proceeded to the task of construction of the spatial information system adopting, as the basis of this job, digital maps and forest databases obtained from the Złotów Forest District. Three polygon layers: 1) forests, 2) towns and 3) lakes, as well as three line layers: 1) public roads, 2) forest roads and 3) rivers and ditches were employed. Next, all features describing forests of the examined object derived from the database such as, for example: tree species, age of trees, their height, closure etc. were added to the system and later two new layers:

ROADS and POINTS were created. Objects placed on the digital map were assigned unique identification labels which allowed connecting all the objects (points, lines and polygons) with appropriate databases. The system prepared in this way made it possible to prepare many variants of courses of touristic paths in relation to the adopted criteria. The authors used the ArcGIS software packages of the ESRI Company to manage all the collected pieces of spatial information and the databases associated with them.

The development of specific pathways involved visualization of the map of the selected category of points, roads and forest areas and then selection of the optimal course of the path taking into consideration the requirements and recommendations described in literature [Antczak 2003, Chrzanowski 2003, Kasprzyk 1997, Skrętkowicz 2003, Ważyński 1997, Zawadzka 2002]. In order to create a theme path, points belonging to a selected category were identified, while roads were classified from the point of view of either their attractiveness or method of transport. Additionally, it was possible to create sub-classifications of the surrounding forests with regard to a selected trait, e.g. tree age or tree species. Once the course of the route was decided on, points and roads were assigned appropriate identifiers. The final step in the process was the verification of the created pathway directly in the forest and its possible correction on the map.

The system of spatial information developed in this way makes it possible to generate many variants of paths characterised by different themes. This type of system can be elaborated for, practically speaking, any forest complex, provided that earlier, appropriate information in the field has been collected. The selected path variants can either be marked permanently in the forest or indicated only in the guidebook which the tourists carry with them. Furthermore, it is also possible to employ more advanced informatics technologies and definite variants of routes can be sent to potential tourists by wireless computer network and an appropriate electronic receiver device. In such a situation, it is not necessary to mark the course of the pathway in the forest because the user equipped with a Global Positioning System (GPS) and mobile internet (e.g. mobile phone with the WAP technology) obtains all the required current information. This can easily be a system similar to that used in car navigation, or somewhat more advanced, and extended with various multimedia data concerning individual points.

## RESULTS

The field inventory performed in the “Zwierzyniec” forest complex allowed the authors to identify 40 educational points (Table 1). In the case of ten points, their attractiveness was described as ‘high’, in the case of 28 – as ‘moderate’ and in 2 cases – as ‘low’. From the point of view of the theme category, the greatest number of places were assigned to the category of PLANTS (32) and FOREST (13). The least numerous were the following categories: HISTORICAL PLACES (2) and GEOMORPHOLOGY (3).

The total of 113 segments of roads were inventoried in the examined “Zwierzyniec” Forest and their total length was over 13 km; 16% of these roads were described as highly attractive, 30% – as moderately attractive and 54% – as not very attractive. The most interesting road segments were those which were accessible only for persons on foot, 72% of which were assigned to the category of high attractiveness, while roads accessible for cars were the least interesting and were assigned to the category of low attractiveness (Table 2).

Table 1. Points of ecological education in the Zwierzyniec Forest and their theme categories and attractiveness

Tabela 1. Punkty edukacji ekologicznej w Lesie Zwierzyniec oraz ich kategorie tematyczne i stopnie atrakcyjności

Point number Numer punktu	Theme categories – Kategoria tematyczna								Point attractiveness Atrakcyjność punktów
	K1	K2	K3	K4	K5	K6	K7	K8	
1	2	3	4	5	6	7	8	9	10
1	x	x	x						moderate – średnia
2		x	x	x	x	x			moderate – średnia
3		x	x						low – mała
4							x	x	high – duża
5					x				moderate – średnia
6		x						x	moderate – średnia
7								x	moderate – średnia
8		x	x		x				high – duża
9	x	x							moderate – średnia
10	x	x							moderate – średnia
11	x	x							moderate – średnia
12	x	x							moderate – średnia
13	x	x							moderate – średnia
14		x						x	moderate – średnia
15		x			x	x			high – duża
16		x	x					x	high – duża
17					x		x		high – duża
18			x		x	x		x	moderate – średnia
19		x							moderate – średnia
20	x	x							moderate – średnia
21		x	x						moderate – średnia
22		x						x	high – duża
23		x							moderate – średnia
24	x	x							high – duża
25		x						x	moderate – średnia
26	x	x							moderate – średnia
27		x							moderate – średnia
28		x	x	x	x	x			high – duża
29	x	x	x						moderate – średnia

Table 1 – cont. / Tabela 1 – cd.

1	2	3	4	5	6	7	8	9	10
30		x							low – mała
31		x							moderate – średnia
32	x	x							moderate – średnia
33		x	x						moderate – średnia
34	x	x							moderate – średnia
35	x	x							moderate – średnia
36		x							moderate – średnia
37					x				moderate – średnia
38					x			x	high – duża
39				x					moderate – średnia
40		x							high – duża

Theme categories: K1 – forest, K2 – plants, K3 – animals, K4 – geomorphology, K5 – water, K6 – seasonal changes, K7 – historical places and K8 – other interesting things.

Kategorie tematyczne: K1 – las, K2 – rośliny, K3 – zwierzęta, K4 – geomorfologia, K5 – woda, K6 – zmiany sezonowe, K7 – miejsca historyczne, K8 – inne interesujące rzeczy.

Table 2. Road categories in the Zwierzyniec Forest and their characterisation (number of road segments, total road length of individual categories and the percentage proportion of roads in degrees of attractiveness)

Tabela 2. Kategorie dróg w Lesie Zwierzyniec i ich charakterystyka (liczba odcinków drogi, łączna długość dróg poszczególnych kategorii oraz procentowy udział długości dróg w stopniach atrakcyjności)

Road categories Kategoria drogi	Number of sections Liczba odcinków	Total length Łączna długość m	Road attractiveness, % Atrakcyjność dróg, %		
			high wysoka	moderate średnia	low niska
Accessible to cars Dostępne dla samochodów	16	2 076	–	–	100
Accessible to wheelchairs Dostępne dla wózków	57	7 151	21	31	48
Accessible to bicycles Dostępne dla rowerów	31	3 186	6	48	46
Accessible to pedestrians Dostępne dla pieszych	9	609	72	7	21
Total Razem	113	13 022	16	30	54

Figure 3 shows the proposed course of the educational path for the theme category ANIMALS. All 10 points belonging to this category were used when designing this pathway and 4 of them were assigned high attractiveness. The route has a shape of a loop 2952 m long and can be started from any place, e.g. in the town of Złotów. The path is accessible only to person on foot because its one segment, 104 m long, is not accessible to any vehicles. The path is characterised by varying attractiveness: 31% of its length is highly attractive, 35% – moderately attractive and 34% – presents low attractiveness.

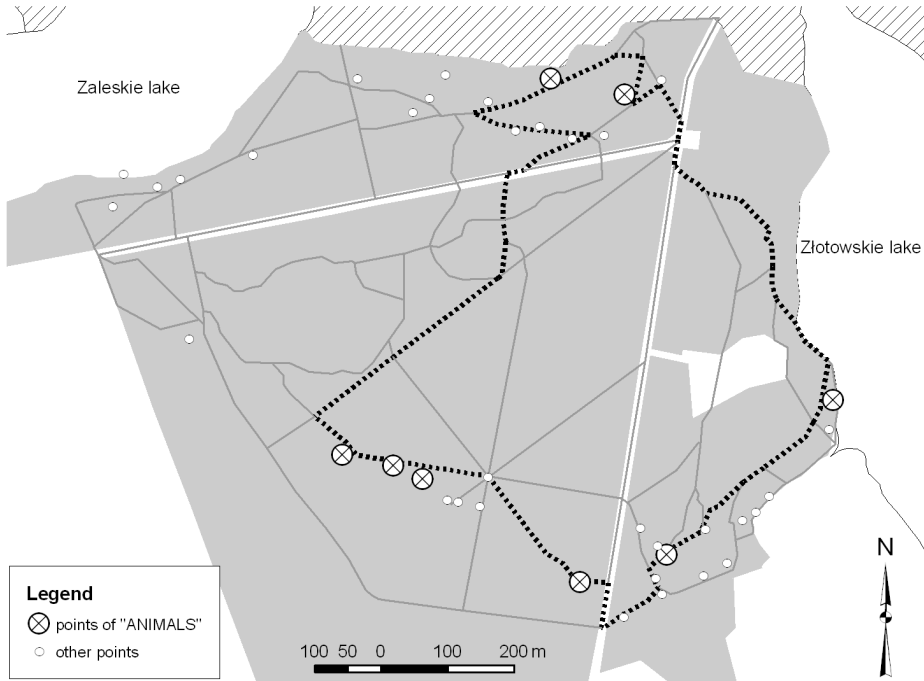


Fig. 3. Proposed course of the educational pathway for the theme category ANIMALS  
Rys. 3. Przykład ścieżki edukacyjnej o kategorii tematycznej ZWIERZĘTA

Figure 4 presents a proposal of a path dedicated to a selected way of transport namely, wheelchairs. It has also a shape of a loop 2812 m long with its beginning and end situated in the town of Złotów. 30% of the length of this route was described as highly attractive. There are 14 educational spots situated along the path and it is possible to utilize all of them or to give up some of them. Before taking the final decision as to which of them to include and which to exclude, it is necessary to check on the spot if it is possible to reach all of them by wheelchair.

After selecting different variants, it is possible to design a specific educational pathway by selecting the variant which appears the most optimal or design a multi-variant pathway.



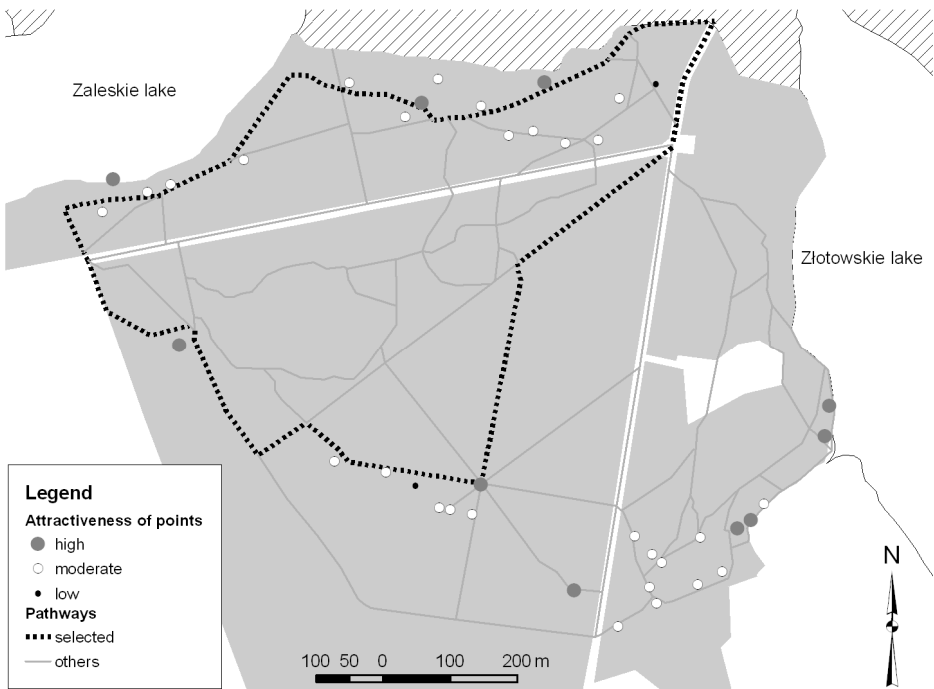


Fig. 4. An example of an educational pathway designed for persons on wheelchairs  
Rys. 4. Przykład ścieżki edukacyjnej przeznaczanej do poruszania się na wózkach inwalidzkich

## CONCLUSIONS

On the basis of the experiments carried out in the Zwierzyniec Forest which concerned designing multi-variant educational pathways with the aid of GIS technology, the following conclusions were drawn:

- In order to elaborate many variants of paths for one forest complex, it is necessary to prepare a detailed inventory carried out directly in the location.
- The GIS system allows the integration of diverse spatial data which can include not only information about educational spots, roads etc. but also data from the local forest district describing forest stands.
- The developed system makes it possible to design many variants of educational pathways in a dynamic way on the basis of specific criteria.
- The multi-variant system of pathways can be supplemented excellently by electronic transfer of information directly to the customer using for this purpose the wireless computer network.

## Acknowledgement

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## WARIANTOWE PROJEKTOWANIE LEŚNYCH ŚCIEŻEK EDUKACYJNYCH Z WYKORZYSTANIEM GIS

**Streszczenie.** Celem pracy było praktyczne sprawdzenie możliwości zastosowania GIS do projektowania wielowariantowych ścieżek edukacyjnych w lesie. Podjęto próbę opracowania systemu zarządzania informacjami przestrzennymi, który pozwala na komponowanie różnych wariantów ścieżek w konkretnym kompleksie leśnym. Jako obiekt badań wybrano Las Zwierzyniec, dawny park przydworski, położony w Nadleśnictwie Złotów. W wyniku przeprowadzonej inwentaryzacji terenowej na terenie kompleksu leśnego Zwierzyniec zlokalizowano 40 punktów edukacyjnych (tab. 1) oraz 113 odcinków dróg o łącznej długości ponad 13 km (tab. 2). Następnie wykonano klasyfikację punktów oraz dróg ze względu na ich atrakcyjność. Drogi podzielono na cztery kategorie ze względu na możliwy sposób poruszania się: 1) dostępne dla samochodów, 2) dostępne dla wózków inwalidzkich, 3) dostępne dla rowerów, 4) dostępne dla pieszych. Punktom przypisano kategorie tematyczne: K1 – las, K2 – rośliny, K3 – zwierzęta, K4 – geomorfologia, K5 –

woda, K6 – zmiany sezonowe, K7 – miejsca historyczne, K8 – inne interesujące rzeczy. Wykorzystując wymienione elementy, zbudowano system informacji przestrzennej umożliwiający tworzenie wielu wariantów tras o różnorodnej tematyce. Wybrane warianty ścieżek mogą być na stałe oznaczone w lesie albo jedynie w przewodniku. Można też posłużyć się zaawansowanymi technologiami informatycznymi i przebieg określonych wariantów ścieżek udostępnić zwiedzającym poprzez bezprzewodową sieć komputerową i elektroniczne urządzenia odbiorcze.

**Słowa kluczowe:** projektowanie wariantowe, leśne ścieżki edukacyjne, rekreacja, edukacja, GIS

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