LANDSCAPE FRAGMENTATION AROUND US – INTEGRATING THE ISSUE INTO EDUCATIONAL PROCESSES AT PRIMARY AND SECONDARY SCHOOLS

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Abstract: The steadily increasing landscape fragmentation and the reduction of permeability for wildlife are among the most negative impacts of human activity on the environment. In terms of education, theseproblems appear to be rather demanding, withthe difficulty corresponding tosecondary school standards. Considering the multiple interdisciplinary connections, the entire process cannot be sufficiently understood without a relevant amount of preliminary knowledge. Such a corpus of information is acquired especially through biology/ecology, geographyand history classes, but links to other subjects can be found too.

The paper presents didactic methods facilitating the actual presentation of the theme to pupils/students; in this context, authors discuss the possibilities of integrating the given problems into applicable schoolsubjects andoutline the risks arising from the proposed modification and/or expansion of the teaching procedures. Also the links to data and supporting methodological materials are included that will allow the teacher to obtain enough information on the topicsto comprehend all the aspects and complexities of the innovated classes. In the corresponding sections, the papercharacterizes individual topics to be combined with

selected teaching methods, especially as regards worksheets, project-oriented education, anda case study relating to afield trip targeting one of the areas of high importance for wildlife migration in the Czech Republic.

Key words: landscape fragmentation; education; didactical methods

INTRODUCTION

One of the most negative human-made impacts on wild life and landscape is the increasing fragmentation of territory and decreasing permeability. The barriers created by anthropogenic activity in landscape limitlong-distance animal migrationson which many species are existentially dependent. In Central and Eastern Europe, the brown bear (*Ursusarctos*), wolf (*Canis lupus*), European lynx (*Lynx lynx*), red deer (*Cervus elaphus*), and moose (*Alces alces*) must be mentioned in this respect. Also everyday movements of common game species are affected. Major barriers are linear transport infrastructure, water courses with regulated banks, fences, built up areas and large forest-less areas (often blocks of arable land). Biotopes suitable for the sustenance of populations are splitin to progressively smaller parts, and the landscape is thus formed from isolated areas that lack sufficient communication with the surroundings; such a trend can then even cause the extinction of the local population (Anděl et al., 2010). The phenomenon of landscape fragmentation was known already before the end of the last century, especially in western European countries (EEA, 2011); in Central and Eastern Europe, the problem gained attentionas a result of the rapid socio-economic changes after the year 1990 (Patru-Stupariu et al., 2015). In addition to the development of the core transport infrastructure, the fragmentation generally accompanied urban sprawl, suburbanisation (Dostál, Havlíček, & Huzlík, 2010; Izakovičová et al., 2017), and, in mountain areas the development of recreational infrastructures (Havlíček & Dostál, 2019). The severity of the problem is also recognised by the responsible authorities, and the requirements for limiting landscape fragmentation have been integrated into strategic documents on spatial planning at the national and international levels (Finka et al., 2018; Semančíková et al., 2020). Conversely, the efforts to reduce fragmentation seem to be very weak, as only between 2000 and 2016 the non-fragmented territory was lost in the Czech Republic, corresponding to approximately 7.5% of the entire country (Dostál, Anděl & Havlíček, 2018).

DIDACTICAL METHODS

From the educational perspective, the problem of landscape fragmentation and relevant changes caused by transport infrastructure is a demanding topic whose difficulty corresponds primarily to high school standards; however, significant portions of the information corpus can be delivered to younger students (pupils) as well. The theme is included inthe more basic subjects, biology/ecology and geography in particular, but links to the subjects such as history, informatics, or mathematics, can be found too. The classic frontal instruction methodis applicable based on data from many different materials available in Czech (Anděl et al., 2010; Dostál et al., 2015; Hlaváč et al., 2019) or English (Iuell et al., 2003).Older students, above all, may be able to convey basic information about landscape fragmentation, in lieu of the classic interpretation, through a 12-minute video[1]; the material, titled “Fragmentacekrajiny”,was produced within the project”Complex

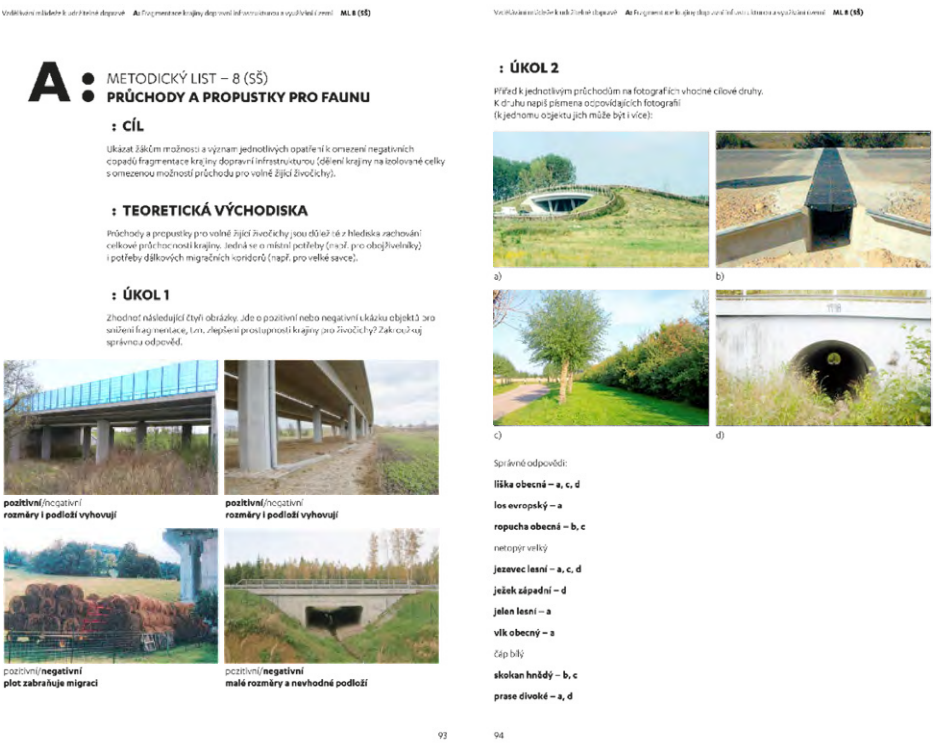
1 https://www.youtube.com/watch?v=ZNMgvfOposU

Approach to the Protection of Fauna of Terrestrial Ecosystems from Landscape Fragmentation in the Czech Republic" (EHP-CZ02-OV-1-028-2015).

To verify the obtained knowledge its understanding, including the broader context, a set of worksheets is available to provide an opportunity for the pupils and students to work independently. The worksheets are created to raise aspects or connections, including intercurricular ones of all, which closely relate to the problem of landscape fragmentation. The topic is well-suitedfor independent work, regardless of whether a gifted individual or a smaller group of pupils is targeted. From the didactic point of view, two specific approaches (with smooth transition in-between) can be defined:

a. Application of selected principles of scientific work: These principles are practised separately or in groups, according to the context and discussed topic. Thus, it is possible to address, for example, data acquisition in one topic and the formulation of a hypothesis in another. The procedure is relatively undemanding and can be easily included in the teaching process, targeting all pupils (see Topics for project-oriented education, topic #1).
b. Independent implementation of the entire research project: In this case, the pupils work separately, and the role of the teacher is based onmethodical supervision. The pupils experience the whole scientific cycle, from topic selection to the final presentation of the results. The procedure is very demanding in terms of the time, material(s), and funds required, with the focus being on talented pupils. (see Topics for project-oriented education, topic #3).

For science subjects, geography and ecology in particular, field teaching is a natural and necessary form ofeducation. Činčera and Holec (2016) analysed a number of studies aimed at research into the effectiveness of field environmental education, concluding that although much of the work illustrates the relatively higher effectiveness of field programs compared to classroom teaching, there are also external barriers (such as time and funding-related issues, the stereotyped school environment, and the teacher's ability to prepare an interesting programme) to its implementation. When implementing individual projects and during field education, it should be remembered that pupils will need to move outside the school building and thus have to be familiar with and adhere to – strictly, where applicable – diverse safety rules. For instance, particular risks are associated with activities near busy roads.



A METODICKÝ LIST – 8 (SŠ)
PRŮCHODY A PROPUSTKY PRO FAUNU

: CÍL

Ukázat žákům možnosti a význam jednotlivých opatření k omezení negativních dopadů fragmentace krajiny dopravní infrastrukturou (dělení krajiny na izolované celky s omezenou možností průchodu pro volně žijící živočichy).

: TEORETICKÁ VÝCHODISKA

Průchody a propustky pro volně žijící živočichy jsou důležité z hlediska zachování celkové průchodnosti krajiny. Jedná se o místní potřeby (např. pro obojživelníky) i potřeby dálkových migračních koridorů (např. pro velké savce).

: ÚKOL 1

Zhodnoť následující čtyři obrázky. Jde o pozitivní nebo negativní ukázku objektů pro snížení fragmentace, tzn. zlepšení prostupnosti krajiny pro živočichy? Zakroužkuj správnou odpověď.

pozitivní/negativní
rozměry i podloží vyhovují

pozitivní/negativní
rozměry i podloží vyhovují

pozitivní/**negativní**
plot zabraňuje migraci

pozitivní/**negativní**
malé rozměry a nevhodné podloží

93

: ÚKOL 2

Přiřaď k jednotlivým průchodům na fotografiích vhodné cílové druhy.
K druhu napiš písmena odpovídajících fotografií
(k jednomu objektu jich může být i více):

a)

b)

c)

d)

Správné odpovědi:

liška obecná – a, c, d
los evropský – a
ropucha obecná – b, c
netopýr velký
jezevec lesní – a, c, d
ježek západní – d
jelen lesní – a
vlk obecný – a
čáp bílý
skokan hnědý – b, c
prase divoké – a, d

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Fig. 1: A sample worksheet representing animal passages (a methodical version for teachers, with comments and correct answers).

Source: Dostál et al., 2015

WORKSHEETS

The set of worksheets constituted one of the main outputs of the previously implemented Project "Youth Education for Sustainable Transport" (Dostál et al., 2015). Two sets were prepared, namely, working (for the pupils) and methodical (for teachers, including the goals, theories, and the correct answers for each task) sheets. Each sheet comprises two to three tasks for the selected topic (Tab. 1, Fig. 1).

Tab. 1: Working and methodical sheets for elementary and high schools

Elementary schools	
1	Perception of landscape
2	Biodiversity and habitat requirements of various fauna species
3	Road-kills, traffic safety, measures to reduce animal mortality, and animal injuries; treatment procedures
4	Monitoring measures to protect landscape permeability
High schools	
1	Landscape definition and functionality; ecosystem services
2	Natural and anthropogenic elements in landscape; landscape typology and character
3	Landscape fragmentation, habitat loss, and their interconnection
4	Connectivity protection concepts; theTerritorial System of Ecological Stability; European green infrastructure
5	Polygonal anthropogenic barriers (settlement, agriculture);natural barriers (watercourses, unsuitable biotopes)
6	Linear anthropogenic barriers (transport), accumulation of barriers, and overall landscape permeability
7	Spreading of invasive species; management of green areas; linear greenery in the vicinity of roads
8	Animal passages andculverts for aquatic and semiaquatic species
9	Secondary environmental effects of transport; history of anthropogenic barriers; preservation of landscape character
10	Strategic level – Strategic Environmental Assessment (SEA), spatial planning; mapping of barriers, migratory studies
11	Project level – Environmental impact assessment (EIA) of individual projects, designing measures to protect landscape permeability

TOPICS FOR PROJECT-ORIENTED EDUCATION

Topic 1: Barriers in the landscape

A topic is to suit smaller groups (ideally 3 pupils/group). The aim is to preparea map output of selected parts of landscape, showing favourable elements for individual categories of species. The pupils should also monitor existing barriers that restrain their free movement through given landscape. During the processing, the participants will learn to distinguish between individual elements in the landscape, their origins, and fitting into an overall frame. Thepupilswill improve in working with topographic maps (or aerial images) and comparing the map content with reality. The output of each group's activity is mainly a map with barriers; in addition, a simple presentation in PowerPoint should be prepared.

Topic 2: Developing a city (municipality)

The second proposed topic lies within the border area between geography and history, and it is also intended for application in smaller groups. The project is focused on the

long-term development of the landscape, with special attention to build-up aselected location by analysing available historical documents. The aim will be to process the historical topographic maps and, where appropriate, aerial images and to compare the development of the built-up area of the municipality in different periods. The output of the entire effort will be a set of maps showing the extent and consequences of urbanization in each period, and an analytic map, colour-coded to indicate the gradual growth of the build-up areas. Similarly, the development of road and rail networks can be processed.

Topic 3: Monitoring of the permeability of passage(s) on selected road/ railway

A topic is suitable for talented students with an advanced interest in sciences, focusing on ecology, geography, and biology. It is not convenient for an entire group of students. The nature of project is monitoring a selected section of a road (or a major railway line) from the perspective of wildlife permeability. The task should include longer-term monitoring of the selected passage in the road by using phototraps, sand bed, and, when weather permits, also snow tracking. Analyses of the results will include evaluation of the images from the phototraps and implementation of the statistics related to the use of the passage by different species of animals. Further, the temporal distribution in relation to the time of the day with regard to the sunset and sunrise may be added. The occurrence of different fauna species can be compared with the "nDOPdatabase"[2] managed byNature Conservation Agency of the Czech Republic.

CASE STUDY – A FIELD EXCURSION FOR STUDENTS TO THE MORAVIAN GATE

A field excursion to a suitably pre-selected area has the potential to illustrate landscape phenomena and relationships that are extremely important for the topic of fragmentation, assuming the right choice of sites and complementary explanations. One of such regions the western part of the Moravian Gate in the vicinity of Lipník nad Bečvou and Hranice, on the migratory route between Jeseníky Mts. and Beskydy Mts. (Jedlička et al., 2019). This area is particularly significant in view of the dispersion migration of individuals living within the core of Beskydy Mts. The Beskydy Mountains is the only territory in the Czech Republic included in the Natura 2000 system with priority protection of all three species of large carnivores. In the Moravian Gate, however, the permeability of the landscape is very limited, because the favourable terrain attracted routes both road and rail, and the spatial development plans include the "Danube-Odra-Labe Canal" and a high-speed railway (Ministry of Transport, 2017).

2 https://portal.nature.cz/nd/

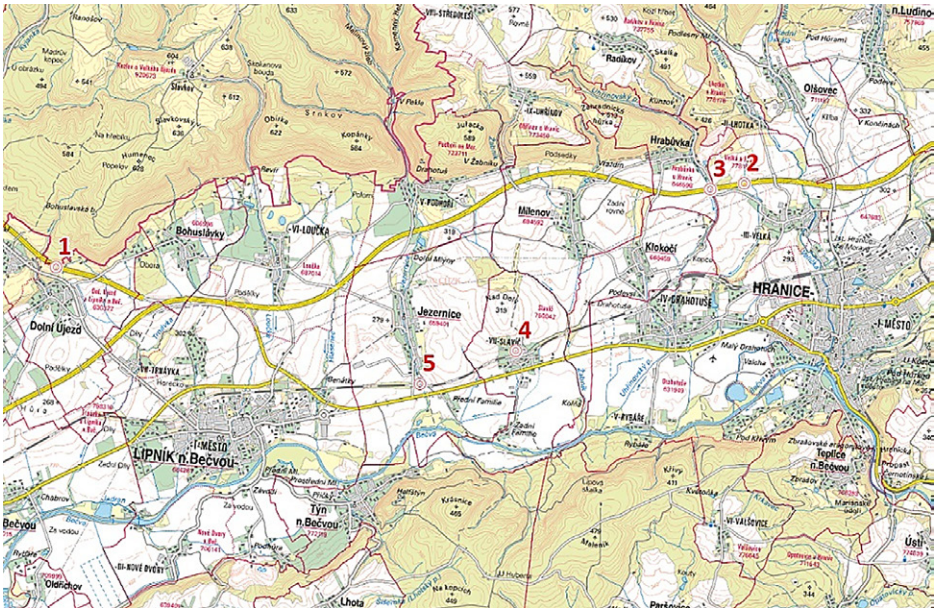

Fig. 2: A survey map of the fieldtrip sites (1 – green bridgeat Dolní Újezd; 2 – landscape bridge near Velká; 3 – bridge Hrabůvka; 4 – the Slavíč tunnel; 5 – viaducts of Jezernice). Background: Base map of the Czech Republic 1 : 50 000

In such a varied and exposed area, a relatively small area has a large number of objects on which various aspects of the subject matter can be illustrated. The following selection (Fig. 2) shows some of the selected sites together with illustrative photographs from practically realized excursions in 2015 with students of the I. German Provincial Gymnasium in Brno and in 2019 with foreign experts from the Enverosinternational project (programme Erasmus+).

Fig. 3: An ecoduct on the D35 expressway, north of Dolní Újezd.

Photo: I. Dostál.

1. The Dolní Újezd green bridge (Fig. 3): the Czech Republic's oldest green bridge was completed in 1999 as a part of the R35 expressway.
2. The landscape bridge near Velká: The bridging of valley formed by the Splavnáwaterstreamis locatedat motorway D1, km 306.8, section Lipník and Bečvou-Bělotín (commissioned in 2008).

Fig. 4: Students near object nr. 2.

Photo: I. Dostál

Fig. 5: Abandoned tunnel in Slavíč.

Photo: I. Dostál

3. The bridge with an aqueduct near Hrabůvka: on the southern outskirts of the Hrabůvka village, a cut-and-cover bridge was built at km 306.1; the structure is used by road III/44023, a gas pipeline, and the Uhřínovskýstream. Functionally, the bridge is associated with the aqueduct, its main role being to transfer locally significant road traffic to minimise disruption of the water regime near the large cut of the highway.
4. The abandoned tunnel in Slavíč village (Fig. 5): Remnants of the original route of the Emperor Ferdinand North Railway (KFNB) from the years 1845–46. Commissioned in 1847, served its purpose until 1895, when a new route was completed only several dozen meters to the south.
5. The viaducts of Jezernice (Fig. 6a, 6b): A technical monument well integrated into the surrounding landscape. A pair of parallel viaducts bridging the broad valley of the Jezernice stream using 42 vaults with a luminosity of 5.7 and 7.6 meters and having a total length of more than 400 meters; the individual components of the structure were completed in 1842 and 1873.

Fig. 6a a 6b: Students near the viaducts of Jezernice.

Photo: I. Dostál

CONCLUSION

Education for sustainable transport, where one of the major components is also landscape fragmentation, is intended to inspire pupils/students to be interested in events that accompany them throughout their lives. Above all, in the upcoming years, the present young generation will already have to deal intensively with transport sustainability from the perspective of fragmentation, generally because if the problem begins to be disentangled only when the population has started to vanish, it will obviously be too late for a successful solution.

It is therefore necessary to raise overall awareness of the issue and to incorporate the topics of landscape fragmentation and wildlife permeability in elementary and high school education. With increasing pressure on landscape, which is becoming evident through the constant expansion of built-up areas and the development of transport infrastructure, the problems will remain critical. The topics are merged with other curricular elements of some basic subjects, prominently including natural history, biology/ecology, and geography; however, links to other subjects can be foundas well. Despite the advantages, the integration of teaching methods other than the frontal approach into the educational process also involves certain risks, especially during outdoor education in close vicinity of transport communications. In addition to safety issues, the conservative management attitudes adopted by some schools, inadequate methodological training of teachers, and, importantly, time and financial difficulties embody significant obstacles to successful implementation. Specific topics for individual teaching approaches are useful especially in the form of methodological and working sheets, and thematically oriented field excursions are also very desirable.

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Shrnutí

Rostoucí míra fragmentace krajiny a snižování průchodnosti pro volně žijící živočichy patří k nejvýznamnějším negativním vlivům lidské činnosti. V rámci vzdělávání patří toto téma k těm náročnějším, svou obtížností odpovídající spíše úrovni střední školy. Má spoustu mezioborových vazeb a celý proces nelze dostatečně pochopit bez širokého spektra znalostí. Téma se prolíná do vice základních vyučovacích předmětů, zejména přírodopisu, biologie/ekologie a zeměpisu, ale lze hledat i vazby na další předměty.

Článek rozebírá jednotlivé didaktické metody vhodné pro prezentaci tématu žactvu, možnosti integrace do výuky jednotlivých předmětů a zdůrazněna jsou také rizika, která při jednotlivých formách výuky na pedagoga či studenta mohou číhat. Zároveň poskytuje odkazy na jednotlivé informační a metodické opory, které umožní pedagogovi načerpat dostatek informací k tématu a uvědomit si všechny vazby ke zvládnutí výuky. Druhá část příspěvku pak představuje možná témata jako konkrétní náměty pro jednotlivé formy výuky, zejména s ohledem na pracovní listy, projektové vyučování a navíc případovou studii realizace tematicky zaměřené terénní exkurze do jedné z oblastí ČR, která má zásadní význam jako migrační koridor.