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BIODIVERSITY IMPACT ASSESSMENT IN ROAD DEVELOPMENT IN LITHUANIA

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Abstract. Roads affect wildlife in different ways. Road construction increases fragmentation of habitats, influences landscape pattern and alters the physical environment. Roads act as barriers to animal movements, increase their mortality rates and cause other negative impacts on biodiversity. The current paper overviews the assessment of road impacts in Lithuania, reviews approaches applied to evaluation of road development impacts as well as analyses application of Lithuanian legal documents in the field. In Lithuania, assessment of possible effects inflicted by envisaged road construction is determined by the Law on Environmental Impact Assessment of Planned Economic Activities and orders of the Ministry of Environment. Although the legislation covers some aspects of biodiversity, little attention is given to the assessment of the impact on biodiversity; meanwhile the impact assessment of proposed economic activities on Natura 2000 sites is clarified more extensively. Lithuanian methodological guidelines on determination of environmental impact assessment procedures and principles for the road network do not comply with international requirements concerning the biodiversity impact assessment of roads. The practiced biodiversity impact assessment used for road development projects in Lithuania complies with minimum requirements used in developed countries. To fulfil international requirements on biodiversity conservation, it is necessary to amend the Lithuanian legislation on environmental impact assessment and issue guidelines on biodiversity protection in road development projects. The article proposes models for calculation of road pollution dispersion for evaluation of air quality next to the already existing and newly projected roads.

Keywords: biodiversity, habitat fragmentation, environmental impact assessment, impact mitigation measures, traffic pollution emission, trace metals, dispersion.

1. Introduction

Road building or reconstruction has an extensive impact on ecological processes and various components of ecosystems (Baltrėnas, Kazlauskienė 2009; Byron 2000; Forman *et al.* 2003). In the more developed countries, the length of roads has increased about 5÷6 times over the past 50 years, thus the territory covered by roads has grown as well. Ament *et al.* (2008) state that in USA, 644 ha of land is destroyed or converted to build 1 kilometre of a road (Ament *et al.* 2008). Thus, not only natural habitats, but also the living environment of most species is destroyed. In Sweden, roads occupy about 5000 km^2, which makes up 1.2% of the entire territory (Seiler, Eriksson 1995). In Lithuania, the road network has been intensively developed over the recent 30÷50 years as well. At present, the length of roads in Lithuania reaches 81331 km making up 2.1% of the entire territory, with 1963055 vehicles running on these roads. Road development not only physically destroys or transforms the home range, but also kills animals. In USA alone, more than 1 million crashes with wild animals take place every year (Ament *et al.* 2008). Moreover, the road traffic pollution has an immense impact on the biological diversity. The road-effect zone covers an area of 500 m from the roadway on each of its side (Forman 2000; Vaiškūnaitė *et al.* 2009; Zhu *et al.* 2002); therefore 1 km of a road has a negatively affected zone amounting to 600 ha. Thus, the road traffic pollutes the environment, induces noise and causes the environment quality degradation. The impact on heterogeneity and fragmentation of landscape and destruction and deterioration of habitats of various species is especially significant (Byron

2000; Morris, Therivel 2009). Epidemiological studies (Balmes *et al.* 2009; Peters *et al.* 1997; Chio, Liao 2008) have demonstrated a greater relationship between health effects and exposures to ultrafine particles compared to the accumulation mode or coarse particles.

Having in mind the long history of road network development efforts, the related environmental impact assessment hardly counts 25÷35 years in most countries. In Sweden, the environmental impact assessment of roads commenced in 1987 (Seiler, Eriksson 1995), while in Lithuania – only in 1997 (Mierauskas *et al.* 1997) with methodological guidelines developed in 1999 (Poveikio aplinkai automobilių… 1999). Especially little attention was paid to ecological evaluation. Much more attention was given to inanimate environment components and human health. Having analysed legal documents of 37 countries (up to 1990), Treweek *et al.* (1993) found an immense insufficiency in focus on ecological evaluation. Analysis of environmental impact assessment statements of the aforementioned countries indicated that only in 35% of statements, some biota field surveys were presented, out of which 31% of statements were ill-timed, e.g. plant records were taken in winter and etc. In 54% of statements, species were calculated without indicating their abundance, rareness status and etc. In 73% of statements, it was recommended to install measures reducing road impacts on natural components or processes; out of them, 51% of statements did not provide any concrete suggestions and only 8% suggested detailed measures of reducing the impact. The presented examples show that up to 1990, the focus on ecological evaluation was insufficient even in developed countries. The focus intensified only subsequent to some essential publications (Canter 1995; Morris, Therivel 2009; Treweek 1999; Trombulak, Frissell 2000).

The main aims of this paper are:

- to analyse the practice of foreign countries in biodiversity impact assessment of road development projects;
- to generalise effectual legal acts of Lithuania on setting the biodiversity impact assessment of planned economic activities;
- to assess the impact of practice applied by road development projects in Lithuania on biodiversity;
- to propose new effective models of pollution dispersion calculation for evaluation of ambient air quality.

2. Biodiversity Impact Assessment in Road Development

2.1. Main Requirements Applied in the Assessment of Road Development Impacts

On the international scale, the Convention on Biological Diversity, Article 14 (1992) obligates every country to undertake biodiversity impact assessment efforts. Meanwhile the *Act on Endangered Species*, which was earlier passed in USA (Endangered Species Act of 1973), required to assess the impact on endangered species and their habitats. The European Communities directive (Council Directive 85/337/EEC… 1985) obligated the member-states to undertake environmental impact assessment and determine biodiversity impacts prior to the Convention endorsement; however concrete obligations of member-states were established in the Habitats Directive (Council Directive 92/43/EEC… 1992). In relation to Natura 2000 sites, Article 6 (3) of the Habitats Directive 92/43/EEC requires that an appropriate assessment of any plans or projects on the site conservation objectives must be carried out to ensure that the integrity of the site is not adversely affected (Council Directive 92/43/EEC… 1992; European Commission 2001). This way, member states are obligated to undertake environmental impact assessment and ensure that the proposed activity has no negative impact on habitats and species at a favourable conservation status, and in the presence of such impact, mitigation measures are required.

Some countries implementing the CBD and other international requirements, issued guidance on biodiversity in EIA. However, ecologists underlined some gaps both from the legal and methodological points of view. Substantial drawbacks of biodiversity impact assessment were indicated subsequent to analysis of development projects delivered in USA, and later – in European and other countries (Andrews 1990; Canter 1995; Forman, Alexander 1998; Hirsch 1993; Morris, Therivel 2009; Seiler, Eriksson 1995; Treweek *et al.* 1993; Trombulak, Frissell 2000). Taking into consideration drawbacks noted by ecologists, executive state institutions of many countries, improved their assessment methodologies. Unfortunately, this cannot be said about the environmental impact assessment methodology in road development in Lithuania (Poveikio aplinkai automobilių… 1999). In methodological guidance on the biodiversity impact assessment of roads, English Nature (Roads and Nature Conservation… 1994) indicated that the biodiversity impact of roads falls into 4 main types: habitat loss, habitat fragmentation, direct and indirect impacts on habitat quality and species, and cumulative impacts. The European Commission prepared the Methodological guidance on assessment of plans and projects significantly affecting Natura 2000 sites (European Commission 2001), on the basis of which the impact on Natura 2000 sites as well as on habitats and species at a favourable conservation status is evaluated.

Interest in the impact assessment of road development projects was increasing not only in guidelines recommended by some state institutions, but also in various research studies. Roads cause both a direct and an indirect loss of habitats. The direct loss refers to the reduction of the total area of an ecosystem caused by presence of roads, while the indirect loss refers to effects such as fragmentation of ecosystems into smaller and more isolated patches and the degradation of ecosystems (Geneletti 2003). Benítez-López *et al.* (2010) investigated development of road infrastructure and discovered that the effect of infrastructure on bird populations extended

over distances up to about 1 km, and for mammal populations – up to about 5 km (Benítez-López *et al.* 2010). Negative impacts of expanding road networks on biodiversity became evident to many researchers. Beyond a doubt, most road projects will lead to some loss of biodiversity but this can be minimised by full use of impact avoidance, mitigation and compensation measures. Therefore, the aim of the environmental impact assessment is to seek that road projects do not significantly reduce biodiversity at any of its levels while enhancing it wherever possible. The proposed guiding principles involved the following main aspects: to avoid impacts on biodiversity and create opportunities for enhancement of biodiversity; to apply the precautionary principle in order to avoid irreversible losses of biodiversity; to consider the full range of impacts on biodiversity (e.g. indirect, cumulative); to retain the existing pattern and connectivity of habitats; to protect natural corridors and avoid artificial barriers; to use buffers to protect important biodiversity areas; to maintain the natural ecosystem process and rare and ecologically important (key) species; and to assess the impact in local, regional, national and international contexts. Besides, decisions on biodiversity should be based on full information and monitoring must be part to the EIA process. Also, management plans for existing and newly created habitats and other mitigation, compensation and enhancement measures should be undertaken (Byron 2000).

To deliver biodiversity impact assessment, criteria for screening and scoping stages were proposed. The main criteria groups were: habitat loss and fragmentation effects, changes in habitat quality (natural processes, pollution, disturbance, management, etc.), key species groups (threatened, rare, protected, endemic, indicator, umbrella, important ecological role, economic and public important and etc.), nationally protected species (e.g. Red List of threatened species), and valued ecosystem components (Byron 2000; Canter 1995; Forman *et al.* 2002; Slootweg *et al.* 2010; Treweek 1999). It was proposed to assess the impact on biodiversity at bioregional, landscape, ecosystem, habitat, species or even population levels. Moreover, especially great attention is paid to protected areas of international (World Heritage and Ramsar sites, Natura 2000, Biospheres reserves and etc.), national and regional importance as well as environmentally sensitive areas. Thus, in many of developed countries, guidelines and methodologies on biodiversity in road EIAs were revised. Primarily, a new systematic approach to biodiversity, minimum survey requirements, revised evaluation criteria, methods on impact assessment and prediction, significance, magnitude of mitigation measures (habitat enhancement, creation an translocation, structures for habitat integrity, eco-corridors and etc.) were adopted. Furthermore, it should be underlined that criteria for assessing the effectiveness of mitigation measures were developed.

Apart from the above mentioned impacts on biodiversity, animal mortality rates due to collisions with traffic and pollution impact should not be forgotten either (Gombert *et al.* 2003; Viard *et al.* 2004). Roads are an obvious factor in magnitude of traffic mortality. To mitigate animal road mortality, special protection measures are applied – guards, tunnels as well as crossovers. But these means are often ineffective (Jaeger *et al.* 2005). Rather often they are installed at inadequate places, without prior investigations regarding the most popular animal migration routes. Therefore, fencing is a frequently raised issue among planning institutions and nature conservationists, as institutions assess the tunnel application efficiency according to their quantity, while conservationists focus on suitability of their structure and location (Forman *et al.* 2002; Jaeger, Fahrig 2004). Hence, discussions regarding efficiency of fencing in reduction or enhancement of animal populations continue to persist.

The negative environmental impact of traffic mostly manifests as noise and exhaust fumes, which are harmful to human health, industry and municipal economy, territorial recreational resources, agriculture and greenery. The global pollution impact was evaluated according to annual emissions of carbon dioxide. The air pollution should not exceed the Highest Permissible Concentrations set for pollutants. The road sanitary zone is determined according to the 'Rules for Establishment of Boundaries and Regime of Sanitary Protection Zones' (see order of Minister of Health – Lietuvos Respublikos… 2004), which state that sanitary protection zones are determined depending on chemical, biologic and physical pollution. A road must have a sanitary zone, where no activities are carried out. According to *the Law on Roads of the Republic of Lithuania* (Kelių įstatymas 1995; Kelių įstatymo… 2002), the width of the sanitary protection zone is determined taking into account the traffic intensity: more than 7000 motorcars per day – 150 m; 3001÷7000 motorcars per day – 70 m; 701÷3000 cars per day – 50 m; 250÷700 cars per day – 20 m. In other cases, the width of the road sanitary protection zone is 10 m.

2.2. Application of Lithuanian Legal Documents for the Impact Assessment of Road Development

The Law on Environmental Impact Assessment of Planned Economic Activities (of 1996, revised in 2005, amended in 2008 and 2010) serves as the legal basis for the environmental impact assessment in Lithuania (Lietuvos Respublikos… 1996, 2005c). The biodiversity impact assessment is determined by legal acts validated by orders of the Minister of Environment with amendments: 'Methodological guidelines on screening of the proposed economic activity' (Lietuvos Respublikos… 2005a), 'Regulation of preparation of environmental impact assessment program and report' (Lietuvos Respublikos… 2005b), 'Guidelines on the quality control of the environmental impact assessment of the proposed economic activity' (Lietuvos Respublikos… 2000) and 'Regulation on assessment of plans and projects significantly affecting potential and designated Natura 2000 sites' (Lietuvos Respublikos… 2006).

On the basis of valid legal acts, the Ministry of Environment published the Manual for Environmental Impact Assessment in Lithuania (Planuojamos ūkinės veiklos… 2009). The publication provides explanations on separate aspects of the environmental impact assessment. Even though the manual hardly focuses on biodiversity impact assessment, environmental impact assessment of the proposed economic activities in respect to Natura 2000 localities is clarified more extensively.

According to 'Methodological guidelines on screening of the proposed economic activity' (Lietuvos Respublikos… 2005a), in biodiversity aspects, the information for screening about territories, where economic activity is planned, should be provided as follows: the protected territory status, especially in case of Natura 2000 sites, its conservation objectives, existing wetlands, and rare or endangered species. The relevance of the impact is assessed by answering 'yes' or 'no' to questions. Besides, factors related to the proposed economic activity and its potential impact on biodiversity are surveyed. The following questions have to be answered: will the project result in loss or damage of habitats of rare and endangered species or will the proposed activity reduce natural habitat areas; will the project negatively affect animal feeding, migration or breeding; will the activity have influence on decrease of species density, the change of resources of hunted animals and trade-significant fish species; will the project generate noise, vibration, light or heat that will have a negative effect on fauna, cause the spread of pests, parasites or invasion species? In methodological regulations, the relevance of the factor is evaluated by answering 'yes' or 'no' to questions. The regulations provide no requirements for taking more factors for a more detailed biodiversity impact assessment. It can be stated that in the screening process, the impact on biodiversity is evaluated rather superficially and does not meet the imposed international requirements or methodologies.

The 'Regulation of preparation of environmental impact assessment program and report' (Lietuvos Respublikos… 2005b) require that the following information about biodiversity should be presented: information about habitats (forests, meadows, wetlands, water bodies, sand dunes) and their location; information about flora (age and type of the forest, species composition, Red List of threatened species and Communities, local and introduced species, plant species of economical significance and their resources, protected greenery and grass-plots), information about local fauna (Red List of threatened species, species composition and their resources, game, fish resources, migratory routes, animal gathering, breeding, feeding, resting and wintering sites), and information about local fungi species and their resources. Besides, potential (predicted) impacts should also be evaluated, comprising the following: changes of the habitat area (ha, a), forest area (%, ha) and age; species composition and type of the forests; destruction of the habitats, changes of animal, plant and fungi species composition, especially of the Red List of threatened species; impact on abundance of species populations, game species, fish resources; destruction of animal migratory routes, reduction of animal gathering, breeding, resting and wintering areas; and threat on the mass destruction of natural environment in case of an accident. Furthermore, measures to mitigate impacts on biodiversity should involve protection, restoration of habitats and species, biological resources, measures envisaged to avoid or mitigate impacts, protect or restore animal migratory routes, and etc. Subsequent to analysis of the requested information on sites where economic activities are planned, it can be stated that it is rather scarce for the purpose of biodiversity impact assessment. By no means this meets the requirements imposed by most of specialists assessing the impact on biodiversity. Besides, the foreseen impact is characterised in very general terms, by answering 'yes' or 'no'. The impact mitigation measures are very general, thus there is a possibility of selecting cheap and ineffective measures.

In order to determine and evaluate whether the assessment of impact on the environment is adequately performed and is consistent with the legal acts, the 'Guidelines on the quality control of the environmental impact assessment of the proposed economic activity' (Lietuvos Respublikos… 2000) were validated. They envisaged assessment of information available in the program and the report, adequacy of the site presentation, alternative consideration, impact on separate environmental components (i.e., biodiversity), and measures envisaged for impact prevention (avoidance), mitigation, restoration or offset. The quality is assessed, whether the factor is relevant and factor requirements have been met, by answering 'ye' or 'no'. For the assessment of impact on biodiversity, it is not foreseen how the qualitative assessment can be carried out. Therefore, the available recommendations cannot ensure that the impact assessment is done properly.

For determination of the impact on Natura 2000 territories, the 'Regulation on assessment of plans and projects significantly affecting potential and designated Natura 2000 sites' (Lietuvos Respublikos... 2006) was validated. The task of the impact assessment on Natura 2000 territories is to determine whether the conservation status of natural habitats and species of the EU importance is observed and whether it would deteriorate or be adversely affected by the integrity of considered territories after implementation of the plan, program or proposed economic activity. The regulation is prepared according to methodological guidance by the European Commission (2001), therefore the main impact assessment requirements are maintained. The regulation determines the process of the significance assessment, but the determination of the impact itself is evaluated by very general requirements. Only the impact significance of separate activity aspects (significant, insignificant or unknown), significance of territory changes (insignificant, slightly significant or significant), significance of impact of separate activity aspects (significant, insignificant or unknown), or significance of territory changes (insignificant, slightly significant or significant)

are evaluated. Following the regulation, the impact can be determined superficially, inaccurately, without consideration of all aspects of the impact on habitats and species. It is not foreseen how prevention, mitigation, avoidance measures are applied in case of significant impact, habitat restoration, translocation or creation. As a whole, the regulation requirements capacitate a superficial significance determination. If performed by unqualified specialists, the impact significance determination would be avoided.

The environmental air evaluation is determined by secondary legislation validated by the order of the Minister of Environment '*On the order of the use of pollutant dispersion calculation models, the data of the environment background pollution and of meteorological data for the evaluation of the impact of economic activity on the ambient air*' (Lietuvos Respublikos… 2007) and the Environment protection agency director order of the Director of Environmental Protection Agency '*On validation of the recommendations for selection of pollutant dispersion calculation models for evaluation of the impact of economic activity on ambient air*' (Aplinkos apsaugos agentūros… 2008), where recommendations for selection of the calculation methodology for air pollutant dispersion are validated and the list of recommended models is presented.

2.3. Survey on Methodology of Impact Assessment of Roads

In 1999, the Ministry of Transport and Communications of the Republic of Lithuania commissioned the Transport and Road Research Institute to prepare the manual, entitled 'Determination of environmental impact assessment procedure and principles in the automobile road system' (Poveikio aplinkai automobilių … 1999). It was based on the revised Law on Environmental Impact Assessment of Planned Economic Activities (Lietuvos Respublikos… 1996) and secondary legislation. This manual lists the main legal acts to be followed in the assessment of road construction and reconstruction. According to the manual, the assessment should be performed taking into consideration the vegetation and fauna state as well as the impact on forests and protected territories, nature frame, and landscape. In the EIA statement, it is recommended to take into consideration rare plant and mushroom habitats, animal species and their migration routes. In the part regarding the statement on forecasted environmental impacts, it is recommended to assess the impact on rare species, forests, and protected territories. The measures reducing the impact and the monitoring program are recommended in a broad outline.

In spite of the fact that in 1999, the mentioned international obligations to preserve biodiversity were undertaken and the significance assessment of impact on Natura 2000 territories and guidelines and methodologies were adopted in many developed countries, these recommendations hardly focused on biodiversity impact. It can be stated that recommendations did not meet either the international and methodological requirements or the applied practice of that time.

2.4. Overview of Practical Impact Assessment in Road Development in Lithuania

The first trials to undertake biodiversity impact assessment in road development in Lithuania took place earlier (Mierauskas, Špakauskas 2008; Mierauskas *et al.* 1997; Pečiulienė, Grigaliūnaitė-Vonsevičienė 2010). These efforts focused on analysis of the general assessment principles and some statements. Therefore, in this chapter, we will try to evaluate the biodiversity impact assessment in road development projects in more detail.

Having analysed environmental impact assessment statements prepared by the Institute of Transport and the Road Research, the biodiversity-related evaluation was performed. The evaluation focused on biodiversity components (species, habitats); protected, available and potential Natura 2000 territories as well as environmentally sensitive, but unprotected territories; a possible impact and proposed measures reducing the impact (impact prevention, avoidance, mitigation, restoration measures); and compensation measures (offset).

Evaluation of information about the sites. The analysed statements contained the following information on biodiversity: general species characteristics, Red List of threatened species and their protection status, and recently – habitats of the EU importance. They describe protected territories, which can be affected by some proposed economic activity (e.g. a road that crosses or is in the vicinity of such territory), their creation objectives as well as Natura 2000 territories (both Special Protection Areas and Special Areas of Conservation), Nature frame, and environmentally sensitive, but not protected areas (wetlands, forests and rivers). Protected territories, which do not border the planned economic activity are not described, mentioning only the distance to such territories as well as stating that there will be no impact on them. Besides, the greenery, which can be affected, is also described. Data on biodiversity differs from case to case: at some localities, special investigations are carried out, while at others – only expert (survey) evaluation is made. Therefore, precise animal and vegetation habitats are provided only in some of the statements. In describing habitats and species of the EU importance, the environmental conditions and impacts, under which favourable conservation status changes and threat to their conservation appears, are not characterised. In general, the provided information is insufficient for a precise identification of impacts and forecasting of appropriate mitigation measures.

Evaluation of a possible biodiversity impact. All statements underline that a road is a barrier with its primary impact on animals, preventing their migration and increasing mortality, which result in decreasing populations. Some statements mention fragmentation of natural habitats, especially of forests and natural meadows, however, the negative impact on concrete habitats and species as well as its manifestation (direct or indirect impact, impact significance or cumulative impact) are not determined. The air, soil, water and noise pollution, which can have a negative impact on biodiversity, is also indicated.

Application of impact mitigation measures (impact prevention, avoidance, mitigation and restoration) and compensation measures (offsets). The most frequently proposed impact reduction measures comprise forest fencing, road tunnels and barriers. They are intended for mammals and are planned in all road construction and reconstruction projects, where roads border forests. Some statements mention plans to install special barriers and tunnels for amphibian. But none of the statement considers or evaluates the tunnel efficiency and suitability for a specific site. Some statements related to installation of bridges over rivulets recommend leaving land strips near the rivulet so that animals could cross to the other side of the road. Other statements recommend destroying the smallest possible area of natural habitats as well as measures for destruction elimination, i.e. meadow renewal and forest planting. When restoring habitats, it is proposed using similar soil in meadows and planting such tree species, which grow in affected forest habitats. When building roads on natural meadows, it is recommended to install overhead roads, thus destroying a smaller habitat area. None of the statements suggest how to mitigate the impact when natural habitats are fragmentized (split) and the habitat translocation (i.e. transfer of affected habitats or their creation in new proper or adjacent territories) is not proposed. It is a costly measure, therefore it is not proposed in any of the statements. It is not recommended to establish parking-lots or sites at places which border Natura 2000 territories. For the reduction of water pollution, it is proposed to install simplified waterworks.

3. The Evaluation of Traffic Pollution Emissions and Choice of the Model for Calculation of Pollution Dispersion at Roadsides

Transport pollution significantly impacts biodiversity. In order to reduce the impact, it is necessary to apply relevant methods to evaluate that impact. Therefore it is very important to know the emissions and spread of pollutants in ambient air resulting from not only the existing roads but also from the newly projected ones. It enables to determine the concentrations of various pollutants in ambient air and draw relevant conclusions regarding their environmental impact.

In modeling the transport pollution impact, the concentrations of CO, NO_2, NO, NO_X, SO_2 and particles are most frequently investigated as only emissions of these pollutants can be estimated sufficiently accurately. The emission amount of these pollutants can be determined when the amount of consumed fuel (Teršalų emisijos… 1993), or the run of automobiles is known (Gkatzoflias *et al.* 2012). For such calculations, the latest software (COPERT 4) is widely used in the EU.

The results of these emissions can be used in calculation of the pollution dispersion using any standard software, but they do not allow determining concentrations of various metals. It is also known that the aerodynamic properties of fine and coarse particles are different; therefore, their dispersion will differ as well. Besides the difference in aerodynamic properties, it appears that various metals have a tendency of spreading with fine or coarse aerosols, and that must be taken into account in modelling the dispersion of pollutants. The particles usually are divided into fine $PM_{2.5}$ – particulate matter with an aerodynamic diameter less than 2.5 μm; coarse PM_{10} – with an aerodynamic diameter ranging between 10 and 2.5 μm; and ultrafine – with an aerodynamic diameter less than 0.1 μm.

The fraction of ultrafine particles according to their aerodynamic properties is very close to the fraction of fine particles, consequently in this work, ultrafine and fine particles will be treated as one fine fraction.

It is well known that the roadside soil contains a lot of accumulated metals, sources of which are: fuel (Pb); lubricants (Zn, Cd, Ba, Co, Mo); tyres (Ca, Zn); catalysts (Pt, Pd, Cr, Ni); protection equipment (Zn, Ca, Cr, Mn); brakes (Zn, Ca, Cu, Cr, Mn); road construction materials (Fe, Al, Mn, As); and resuspension of road dust (Pb, Fe, Al, Mn, Zn, Cu, Ni, Mo, As) (Abu-Allaban *et al.* 2003; Cadle *et al.* 1997).

It is established that Fe is distributed mainly in coarse aerosols, while metals Pb, Zn, Mb, As are distributed mainly in fine aerosols. The resuspension of road dust can be considered as a source of the crustal elements Fe, Al, Mn and As. Road dust becomes enriched with large amounts of Zn due to brake or tyre wear.

The brake wear metals Cu, Ni, Mo, Zn can be considered as a component of coarse aerosols.

We propose the calculation of total metal concentrations using the model we developed based on the experimental measurements:

$$c(x) = c_f + c_0 e^{-kx}, \quad (1)$$

where: c_f is the concentration of background, c_0 is the concentration of metals on the road for the road length unit, g/m^3; x is the distance from the road, m; $k = 0.030$ stands for coarse particles and $k = 0.015$ 1/m, for fine particles.

The spread of metal pollutants on roadsides can be calculated knowing the emission of fuel combustion products and the percentage of metals in the total amount of pollutants emitted on a highway.

We recommend calculating only the concentrations of Mn, Pb, Zn, Cu, Ni, Mo and Cr since these values are considerably higher than the background ones, while the concentrations of the other metals are on the level of background values.

The major amount of pollutants falls out in the range of 30 m from a highway. The deposition of these pollutants on a roadside is conditioned by coarse PM_{10} particles, the concentration of which on the road for the road length unit can be calculated with the help of regression formula (2). The emission factors are presented in Table 1 (COST 346 2005):

$$PM_{10} = 2.2 + 7(\text{dies.exh}) + 3.1(\text{pet.exh}) + 4.4(\text{resusp.soil}) + 9(\text{tyre \& brake}) + 2.5(\text{roadsurf.}). \quad (2)$$

The correlation coefficient R^2 between the model and experimental data, when multi-linear regress equations system was solved is 95%.

When calculating the deposition of aerosols PM_{10} on a roadside, the data of Table 2 can be used (Išmetamų į atmosferą teršalų… 2011).

Concentrations of particular metals can be found knowing what fraction this metal amounts to in the total emission (Išmetamų į atmosferą teršalų… 2011). These data are presented in Table 3.

Thus according to the method of calculation of pollutant concentrations proposed by us, we can without difficulty evaluate the pollution of fine and coarse particles and determine the concentrations of the main heavy metals on roadsides. The only required data for this are the fleet of vehicles on a highway, which can be easily obtained.

Some cases of the spread of pollutants in Lithuania are given in the works of authors (Brannvall, Špakauskas 2007; Martinėnas, Špakauskas 2010; Martinėnas *et al.* 2006) and they can be successfully applied, the more so because they reflect the true climate conditions of Lithuania.

Table 1. Emission factors for PM_{10} particles

Source	Vehicle category	Emission factor, mg/km
Exhaust	LDV	13.9
	HDV	79.3
Resuspension	LDV	0.8
	HDV	14.4
Tyre & brake wear	LDV	6.9
	HDV	49.7
Road surface wear	LDV	3.1
	HDV	29.0

LDV – light duty vehicles;
HDV – heavy duty vehicles

Table 2. PM_{10} emission factors for tyre, brake wear and road abrasion

Transport category	Emission factor, g/km		
	Tyre wear	Brake wear	Road abrasion
Motorcycles	0.0028	0.0020	0.0030
Passenger cars	0.0064	0.0033	0.0075
Light duty vehicles	0.0101	0.0052	0.0075
Heavy duty vehicles and buses	0.0270	0.0130	0.0380

Table 3. Heavy metal fraction of tyre, brake wear and road abrasion in total emission

Heavy metals	Tyre wear mg/kg	Brake wear mg/kg	Road abrasion mg/kg
As	0.8	10.0	0
Cd	2.6	13.2	1
Cr	12.4	669	40
Cu	174	51112	12
Ni	33.6	463	20
Pb	107	3126	15
Zn	7434	8676	35

4. Conclusions

1. Biodiversity impact assessment used in road development projects in most developed countries satisfies the main protection of biodiversity requirements of the Convention on Biological Diversity, the Habitats Directive and national biodiversity strategies.
2. The Lithuanian legislation on the environmental impact assessment, provides minimal requirements on biodiversity conservation. However, legal acts do not comply with international practice used in road development projects.
3. Biodiversity impact assessment used in road development projects in Lithuania comply only with minimal requirements applied in developed countries. To meet the international requirements on biodiversity conservation, it is necessary to amend the Lithuanian legislation on environmental impact assessment and issue the guidelines on biodiversity impact assessment in road development projects.
4. The models for calculation of the spread of pollutants from roads were proposed considering the pollution of various metals, which have an especially harmful environmental impact. They can be applied for evaluation of the present air quality near roads and forecast of the air quality near newly projected roads as well.

References

Abu-Allaban, M.; Gillies, J. A.; Gertler, A. W.; Clayton, R.; Proffitt, D. 2003. Tailpipe, resuspended road dust, and brake-wear emission factors from on-road vehicles, *Atmospheric Environment* 37(37): 5283–5293. http://dx.doi.org/10.1016/j.atmosenv.2003.05.005

Ament, R.; Clevenger, A. P.; Yu, O.; Hardy, A. 2008. An assessment of road impacts on wildlife populations in U.S. national parks, *Environmental Management* 42(3): 480–496. http://dx.doi.org/10.1007/s00267-008-9112-8

Andrews, A. 1990. Fragmentation of Habitat by Roads and Utility Corridors: a Review, *Australian Zoologist* 26(3–4): 130–141.

Aplinkos apsaugos agentūros direktoriaus įsakymas dėl ūkinės veiklos poveikiui aplinkos orui vertinti teršalų sklaidos skaičiavimo modelių pasirinkimo rekomendacijų patvirtinimo. 2008, *Valstybės žinios*, 2008-12-13, Nr. 143-5768 (in Lithuanian).

Balmes, J. R.; Earnest, G.; Katz, P. P.; Yelin, E. H.; Eisner, M. D.; Chen, H.; Trupin, L.; Lurmann, F.; Blanc, P. D. 2009. Exposure to traffic: Lung function and health status in adults with asthma, *Journal of Allergy and Clinical Immunology* 123(3): 626–631. http://dx.doi.org/10.1016/j.jaci.2008.10.062

Baltrėnas, P.; Kazlauskienė, A. 2009. Sustainable ecological development reducing negative effects of road maintenance salts, *Technological and Economic Development of Economy* 15(1): 178–188. http://dx.doi.org/10.3846/1392-8619.2009.15.178-188

Benítez-López, A.; Alkemade, R.; Verweij, P. 2010. The impacts of roads and other infrastructure on mammal and bird populations: a meta-analysis, *Biological Conservation* 143(6): 1307–1316. http://dx.doi.org/10.1016/j.biocon.2010.02.009

Brannvall, E.; Špakauskas, V. 2007. Experimental and theoretical study of pollutant dispersion along a highway, *Geologija* 60: 27–32.

Byron, H. 2000. *Biodiversity Impact: Biodiversity and Environmental Impact Assessment: A Good Practice Guide for Road Schemes*. The Royal Society for the Protection of Birds. 119 p.

Cadle, S. H.; Mulawa, P. A.; Ball, J.; Donase, C.; Weibel, A.; Sagebiel, J. C.; Knapp, K. T.; Snow, R. 1997. Particulate emission rates from in-use high-emitting vehicles recruited in orange county, California, *Environmental Science and Technology* 31(12): 3405–3412. http://dx.doi.org/10.1021/es9700257

Canter, L. W. 1995. *Environmental Impact Assessment*. 2nd edition. McGraw-Hill Science/Engineering/Math. 480 p.

Išmetamų į atmosferą teršalų tyrimai, įvertinimas, prognozė bei antropogeninės taršos lygių ir kritinių apkrovų ekosistemoms vertinimas. 2011. Ataskaita. Sutartis Nr. 4F10-76. 2010 m. birželio mėn. 17 d. Fizinių ir technologijos mokslų centras, Vilnius. 91 p. Available from Internet: http://gamta.lt/files/Emisiju_ataskaita_2009.pdf (in Lithuanian).

Chio, C.-P.; Liao, C.-M. 2008. Assessment of atmospheric ultrafine carbon particle-induced human health risk based on surface area dosimetry, *Atmospheric Environment* 42(37): 8575–8584. http://dx.doi.org/10.1016/j.atmosenv.2008.08.027

Convention on Biological Diversity. 1992. UNCED (United Nations Conference on Environment and Development). 3–14 June 1992, Rio de Janeiro, Brazil. Available from Internet: http://www.cbd.int/convention/text

COST 346. 2005. *Energy and Fuel Consumption from Heavy Duty Vehicles*. Final Report of the Action.

Council Directive 85/337/EEC of 27 June 1985 on the Assessment of the Effects of Certain Public and Private Projects on the Environment. 1985. Available from Internet: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1985:175:0040:0048:EN:PDF

Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora. 1992. Available from Internet: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0043:EN:NOT

Endangered Species Act of 1973 [Public Law 93–205, Approved Dec. 28, 1973, 87 Stat. 884].

European Commission 2001. *Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites: Methodological Guidance on the Provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC*. 76 p. Available from Internet: http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/natura_2000_assess_en.pdf

Forman, R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States, *Conservation Biology* 14(1): 31–35. http://dx.doi.org/10.1046/j.1523-1739.2000.99299.x

Forman, R. T. T.; Sperling, D.; Bissonette, J. A.; Clevenger, A. P.; Cutshall, C. D.; Dale, V. H.; Fahrig, L.; France, R. L.; Goldman, C. R.; Heanue, K.; Jones, J.; Swanson, F.; Turrentine, T.; Winter, T. C. 2002. *Road Ecology: Science and Solutions*. 1st edition. Island Press. 504 p.

Forman, R. T. T.; Alexander, L. E. 1998. Roads and their major ecological effects, *Annual Review of Ecology and Systematics* 29: 207–231. http://dx.doi.org/10.1146/annurev.ecolsys.29.1.207

Geneletti, D. 2003. Biodiversity impact assessment of roads: an approach based on ecosystem rarity, *Environmental Impact Assessment Review* 23(3): 343–365. http://dx.doi.org/10.1016/S0195-9255(02)00099-9

Gkatzoflias, D.; Kouridis, C.; Ntziachristos, L.; Samaras, Z. 2012. *COPERT 4 Computer Programme to Calculate Emissions from Road Transport – User Manual (version 9.0)*. ETC–ACC (European Topic Centre on Air and Climate Change). 70 p. Available from Internet: http://www.emisia.com/docs/COPERT4v9_manual.pdf

Gombert, S.; Asta, J.; Seaward, M. R. D. 2003. Correlation between the nitrogen concentration of two epiphytic lichens and the traffic density in an urban area, *Environmental Pollution* 123(2): 281–290. http://dx.doi.org/10.1016/S0269-7491(02)00367-6

Hirsch, A. 1993. Improving consideration of biodiversity in NEPA assessments, *Environmental Professional* 15(1): 103–115.

Jaeger, J. A. G.; Bowman, J.; Brennan, J.; Fahrig, L.; Bert, D.; Bouchard, J.; Charbonneau, N.; Frank, K.; Gruber, B.; Tluk von Toschanowitz, K. 2005. Predicting when animal populations are at risk from roads: an interactive model of road avoidance behavior, *Ecological Modelling* 185(2–4): 329–348. http://dx.doi.org/10.1016/j.ecolmodel.2004.12.015

Jaeger, J. A. G.; Fahrig, L. 2004. Effects of road fencing on population persistence, *Conservation Biology* 18(6): 1651–1657. http://dx.doi.org/10.1111/j.1523-1739.2004.00304.x

Kelių įstatymas. 1995, *Valstybės žinios*, 1995-05-26, Nr. 44-1076 (in Lithuanian).

Kelių įstatymo pakeitimo įstatymas. 2002, *Valstybės žinios*, 2002-10-23, Nr. 101-4492 (in Lithuanian).

Martinėnas, B.; Brannvall, E.; Špakauskas, V. 2006. Fine particles spread into the roadside model and typical of its distribution, *The Baltic Journal of Road and Bridge Engineering* 1(3): 123–128.

Martinėnas, B.; Špakauskas, V. 2010. Simulation of traffic pollution dispersion near roadways, *Lithuanian Journal of Physics* 50(2): 255–260. http://dx.doi.org/10.3952/lithjphys.50212

Mierauskas, P.; Špakauskas, V. 2008. Ecological evaluation of road environment impact assessment statements, in *Proceedings of 7th International Conference 'Environmental Engineering'*, 22–23 May, 2008, Vilnius, Lithuania, 1–5 [CD].

Mierauskas, P.; Lygis, D.; Greimas, E. 1997. Ekologinis vertinimas kelių plėtros projektuose, *Aplinkos inžinerija* 2(8): 50–55 (in Lithuanian).

Lietuvos Respublikos planuojamos ūkinės veiklos poveikio aplinkai vertinimo įstatymas. 1996, *Valstybės žinios*, 1996-08-30, Nr. 82-1965 (in Lithuanian).

Lietuvos Respublikos aplinkos ministro įsakymas dėl planų ar programų ir planuojamos ūkinės veiklos įgyvendinimo poveikio įsteigtoms ar potencialioms „Natura 2000" teritorijoms reikšmingumo nustatymo tvarkos aprašo patvirtinimo. 2006, *Valstybės žinios*, 2006-05-31, Nr. 61-2214 (in Lithuanian).

Lietuvos Respublikos aplinkos ministro įsakymas dėl planuojamos ūkinės veiklos atrankos metodinių nurodymų patvirtinimo. 2005a, *Valstybės žinios*, 2006-01-12, Nr. 4-129 (in Lithuanian).

Lietuvos Respublikos aplinkos ministro įsakymas dėl planuojamos ūkinės veiklos poveikio aplinkai vertinimo atlikimo kokybės įvertinimo atmintinės patvirtinimo. 2000. *Valstybės žinios*, 2000-08-02, Nr. 65-1971 (in Lithuanian).

Lietuvos Respublikos aplinkos ministro įsakymas dėl poveikio aplinkai vertinimo programos ir ataskaitos rengimo nuostatų patvirtinimo. 2005b, *Valstybės žinios*, 2006-01-17, Nr. 6-225 (in Lithuanian).

Lietuvos Respublikos aplinkos ministro įsakymas dėl teršalų sklaidos skaičiavimo modelių, foninio aplinkos oro užterštumo duomenų ir meteorologinių duomenų naudojimo tvarkos ūkinės veiklos poveikiui aplinkos orui įvertinti. 2007, *Valstybės žinios*, 2007-12-06, Nr. 127-5189 (in Lithuanian).

Lietuvos Respublikos planuojamos ūkinės veiklos poveikio aplinkai vertinimo įstatymo pakeitimo įstatymas. 2005c, *Valstybės žinios*, 2005-07-12, Nr. 84-3105 (in Lithuanian).

Lietuvos Respublikos sveikatos apsaugos ministro įsakymas dėl sanitarinių apsaugos zonų ribų nustatymo ir režimo taisyklių patvirtinimo. 2004, *Valstybės žinios*, 2004-09-02, Nr. 134-4878 (in Lithuanian).

Morris, P.; Therivel, R. 2009. *Methods of Environmental Impact Assessment*. 3rd edition. Routledge. 576 p.

Pečiulienė, M.; Grigaliūnaitė-Vonsevičienė, G. 2010. Research on change of natural radionuclide radiation above highways pavement in Lithuania, *The Baltic Journal of Road and Bridge Engineering* 5(1): 5–9. http://dx.doi.org/10.3846/bjrbe.2010.01

Peters, A.; Wichmann, H. E.; Tuch, T.; Heinrich, J.; Heyder, J. 1997. Respiratory effects are associated with the number of ultrafine particles, *American Journal of Respiratory and Critical Care Medicine* 155(4): 1376–1383.

Planuojamos ūkinės veiklos poveikio aplinkai vertinimo vadovas. 2009. Lietuvos Respublikos aplinkos ministerija. 107 p. Available from Internet: http://www.am.lt/VI/files/0.519685001249378224.pdf (in Lithuanian).

Poveikio aplinkai automobilių kelių sistemoje vertinimo procedūrų bei principų nustatymas. 1999. VĮ „Transporto ir kelių tyrimo institutas" (TKTI). Kaunas. 49 p. (in Lithuanian).

Seiler, A.; Eriksson, I. M. 1995. New approaches to integrate landscape ecological concepts in road planning in Sweden, in *Proceedings of the International Conference on Habitat Fragmentation, Infrastructure, and Role of Ecological Engineering*, 143–155.

Slootweg, R.; Rajvanshi, A.; Mathur, V.; Kolhoff, A. 2010. *Biodiversity in Environmental Assessment*. Cambridge University Press. 456 p.

Roads and Nature Conservation: Guidance on Impacts, Mitigation and Enhancement. 1994. Peterborough. English Nature. 84 p.

Teršalų emisijos į atmosferą iš mašinų su vidaus degimo varikliais apskaičiavimo metodika. 1993. Lietuvos Respublikos aplinkos ministerija. Vilnius. 64 p. (in Lithuanian).

Treweek, J. 1999. *Ecological Impact Assessment*. 1st edition. Wiley-Blackwell. 368 p.

Treweek, J. R.; Thompson, S.; Veitch, N.; Japp, C. 1993. Ecological assessment of proposed road developments: a review of environmental statements, *Journal of Environmental Planning and Management* 36(3): 295–307. http://dx.doi.org/10.1080/09640569308711948

Trombulak, S. C.; Frissell, C. A. 2000. Review of ecological effects of roads on terrestrial and aquatic communities, *Conservation Biology* 14(1): 18–30. http://dx.doi.org/10.1046/j.1523-1739.2000.99084.x

Vaiškūnaitė, R.; Laurinavičius, A.; Miškinis, D. 2009. Analysis and evaluation of the effect of studded tyres on road pavement and environment (II), *The Baltic Journal of Road and Bridge Engineering* 4(4): 203–211. http://dx.doi.org/10.3846/1822-427X.2009.4.203-211

Viard, B.; Pihan, F.; Promeyrat, S.; Pihan, J.-C. 2004. Integrated assessment of heavy metal (Pb, Zn, Cd) highway pollution: bioaccumulation in soil, Graminaceae and land snails, *Chemosphere* 55(10): 1349–1359. http://dx.doi.org/10.1016/j.chemosphere.2004.01.003

Zhu, Y.; Hinds, W. C.; Kim S.; Sioutas, C. 2002. Concentration and size distribution of ultrafine particles near a major highway, *Journal of the Air and Waste Management Association* 52(9): 1032–1042. http://dx.doi.org/10.1080/10473289.2002.10470842