SPATIUM *International Review*
No. 31, July 2014, pp. 66-73

UDC 502.4(497.113)
Original scientific paper
DOI: 10.2298/SPAT1431066K

ASSESSMENT OF THE CAPACITY OF THE NATIONAL ECOLOGICAL NETWORK ELEMENTS FOR ROAD CONSTRUCTION AND OPERATION

Vesna Kicošev[1], Institute for Nature Conservation of Vojvodina Province, Novi Sad, Serbia
Laslo Galamboš, Institute for Nature Conservation of Vojvodina Province, Novi Sad, Serbia
Ivan Čizmić, Road Center of Vojvodina, Novi Sad, Serbia
Đorđe Mitrović, Public Enterprise "Roads of Serbia", Belgrade, Serbia

Road construction and usage have a wide range of direct and indirect negative effects on protected areas. The impact of state roads on protected areas in Vojvodina was reviewed in this article, based on the orientation values of habitat loss and secondary negative effects originating from traffic functioning. Results of the assessment indicate that the use of existing roads constructed on habitats within the national ecological network exceeded the capacity of individual PA-protected areas (e.g., in case of Straža Natural Monument). Recorded capacity overflow on other PAs occurs solely as a consequence of overlapping between protected areas and areas of influence of roads routed along the borders of protected areas (which is the case with Slano Kopovo Special Nature Reserve and Selevenjske pustare Special Nature Reserve). The aim of this article is to show that even with the smallest values of the parameters related to the width of roads and critical distance from the habitat, the vulnerability of certain core areas of the national ecological network is evident.

Key words: Vojvodina Province, protected areas, state roads, habitat loss.

INTRODUCTION

Biodiversity preservation and ecosystem protection represent the prerequisite for maintaining the functionality of biosphere and its structural elements. Damaged and/or degraded ecosystems as entireties have decreased tolerance towards environmental changes (Noss, 2001). In areas where the market increasingly swallows up space (contributing to the shaping of the form and functions according to a profit-based logic), one of the main causes of the changes in the environment is land use modification so the protection policy should significantly influence spatial development programmes and consequently land management (Lisec and Drobne, 2009, EEA, 2010, Balestrieri, 2013). Construction and usage of roads have a broad spectrum of both direct and indirect ecological impacts. Compared to other types of infrastructure, the construction and usage of roads causes most changes in environmental conditions in areas which are several times greater than the surface of the traffic corridor itself. The numerous adverse impacts, which are more visible in paved roads and which proportionally increase with the frequency of traffic, mainly occur synchronously (Trombulak and Frissell, 2000, Szabados and Kicošev, 2006). The degree of impact on the population depends on the characteristics and behaviour of particular species, the physical properties of the road and accompanying infrastructure, characteristics of road transport and spatial configurations regarding the surrounding landscape (Coffin, 2007). Traffic is considered to be one of the main causes of populations' decline in many endangered species (Jaarsma *et al.*, 2006). Roads routed on the edge of wetlands cut through the migratory pathways of animals, separating them from key survival resources: drinking water or breeding habitats (Szabados and Panjković, 2009). Habitat fragmentation caused by construction and usage of roads has a wide range of negative impacts on plant and animal communities. These were observed for mammals (Oxley *et al.*, 1974, Lankester *et al.*, 1991, Clarke *et al.*, 1998, Huijser and Bergers, 2000, Ćirović and Kureljeušić, 2012), certain bird species (Develey and Stouffer, 2001, Clevenger *at al.*, 2003, Stojnić, 2004), insects (Vermeulen, 1994, Bhattacharya *et al.*, 2003) and herpetofauna (Pantelić, 1995, Hels and Buchwald, 2001, Aresco, 2005). The most probable cause of regional extinction of species such as the badger (*Meles meles*), is mortality caused by road kill (Lankester *et al.*, 1991, Clarke *et al.*, 1998). The edge effect (change in quality of the environment, microclimate parameters, noise, illumination, etc.) can span up to a few hundred meters on both sides of the road (Gilbert *et al.*, 2003, Seiler and Folkeson, 2006, Brugge *et al.* 2007, Beckerman *et al.*, 2008, Hagler *et al.*, 2009) which, along with the cumulative environmental effects associated with other forms of land use (Willard and Marr 1971,

[1]Radnička 20a, 21000 Novi Sad, Serbia
vesna.kicosev@pzzp.rs

Godefroid and Koedam, 2004) causes changes in the composition and structure of communities (Farmer, 1993, Forman and Deblinger, 2000) and may result in the destruction of existing ecosystems (Coffin, 2007).

Traffic emits at least 40 different types of pollutants (HEI, 2010), a large fraction of which settles within a 100-200m wide strip along the roads (Roorda-Knape *et al.*, 1998, Zhu *et al.*, 2002, Gillbert *et al.*, 2003), downwind from 500m (Zhou and Levy, 2007, Suzuki and Brauer, 2012), up to 800m (Reponen *et al.*, 2003). About half of the amount of emitted particle matter deposits within a 100-150 m wide strip (Hitchins *et al.*, 2000), and a significant portion of this amount settles in the area of up to 50m (Tiitta *et al.*, 2002). The negative effects of traffic must include the sensitivity to lighting, noise and vibration. The impact of these factors on wildlife depends on species biology (type of locomotion, diet, reproduction, etc.) along with significant differences in the distance from the emission source in the horizontal and vertical directions. Research on birds (e.g. Palominoa and Carrascal, 2007) indicates that the impact area is 300m away from the main road.

Even though the majority of scientific articles in the field of environmental protection refer to impacts of roads with average frequency above 10,000 vehicles/day, ecological research indicates that local roads can cause significant damage to habitats (Forman *et al.*, 2003, Van Langeveld *et al.*, 2008). Roads with a traffic frequency of 500 vehicles/day may function as a sink to certain species inhabiting the nearby habitats, while negative effects of traffic noise were recorded already at the frequency of 200 vehicles/day (Mumme *et al.*, 2000).

MATERIALS AND METHODS

The impacts of state roads on protected areas in Vojvodina were analysed in this article, by assessing both the endangerment of these areas based on classes of orientation values of habitat loss (by direct occupation of the area) and the secondary negative effects of traffic related to sedimentation of emitted pollutants. Remaining secondary negative effects related to traffic impact (noise, vibration, lights etc.) were not taken into consideration in this assessment. The establishment of protected areas enables the protection of spatial units that have more or less preserved natural conditions necessary for the survival of endangered organisms (Kicošev and Szabados, 2007). Their integration into the national, regional and continental networks represents one of the priority tasks of modern conservation biology (Hannah *et al.*, 2002). At the European Union (EU) level it is carried out under the 'Natura 2000' project (Hicks *et al.*, 2011), by designating special areas for conservation of habitats and species (Special Area of Conservation) and areas for conservation of birds (Special Protection Area). On a country level, this is being achieved by establishing national ecological networks (Kicošev *et al.*, 2011). The primary goal of the establishment of the national ecological network in the Republic of Serbia is the protection of habitats and migratory areas of protected species, but it also has an important role in general biodiversity conservation, protection of environment quality and sustainable development of the areas (Kicošev *et al.*, 2013).

The determination and design of areas as potential elements of the ecological network is carried out by the use of the 'Ecological Network' module of the Electronic database that is being operated by the Institute for Nature Conservation of Vojvodina Province (INCVP). These sites are regularly included into the spatial and urban plans (Kicošev *et al*, 2013). Since the officially designated list of habitats and ecological corridors outside the protected areas (that will become an integral part of the ecological network) didn't exist during the research period undertaken for the purpose of this article, the potential overlap of these elements with the road infrastructure was not considered. Classes of orientation values were obtained by using absolute and relative values of habitat loss. These were defined for the Appropriate Assessment (AA) of projects for the purpose of conservation of the Natura 2000 EU ecological network. Absolute and relative values of habitat loss were determined using an expert methodology (Lambrecht and Trautner, 2007) originating from Germany, which has advanced the furthest in quantifying the potential endangerment of habitats. The part of the mentioned methodology which refers to relative habitat loss is used in this article. The methodology was selected due to its compatibility with the purposes of preservation of the functionality of the national ecological network. According to the current practice in Serbia, the clearly defined rules of spatial planning have established a more effective arrangement of contents (e.g. infrastructure) in accordance with the sensitivity and capacity of the area, as well as a better acceptance of the obligations of business entities related to nature protection. In contrast to this approach, most of the other countries in the EU are resolving the problems of habitat loss usually 'case by case'. Table 1, which is used to determine the potential loss of habitat by the impact of road infrastructure, represents an adaptation of this methodology in accordance with the specifics of the protected areas in Serbia. Since habitat types selection (that would become the core areas of the Natura 2000 network in the future), is currently on-going in Serbia, the data for the core areas of the NEN were used to represent the vulnerability. The adaptation of the original tables by Lambrecht and Trautner (2007) has been done based on the available data on the range of values of habitat surface (work in progress by INCVP). Apart from this, the national Red List Assessment of Habitat Types of Serbia also hasn't been adopted. The Red List would have a significant importance in the determination of levels of relative habitat loss and classes of orientation values. Therefore, changes in Table 1 are possible upon the establishment of the Natura 2000 in Serbia.

The potential threats to habitats generated by secondary effects of traffic were assessed by the analysis of the available published data on the effects of pollutant deposition. In order to be able to apply the obtained results of this assessment, the analysed effects of roads on habitats are related to the pollutant deposition in the environment, disregarding the type of vehicle as an emission source. Analysing the documentation of Public Enterprise 'Roads of Serbia' related to the EIA-environmental impact assessment studies of the construction of certain sections of E-75, E-80 and E-763 state roads, it was found that up to a certain distance away from the road, nitrogen dioxide and benzene concentrations (calculated according to the Merkblatt über Luftverunreinigungen an Straßen, MLuS 92 model) exceeded the maximum allowed values, prescribed by the Ordinance on Thresholds, Emission Measuring Methods, Criteria for Establishing Measurement Points and Record Keeping (Official Gazette of the Republic of Serbia 54/92, 30/99 and 19/06). With an

Table 1. Relative habitat loss and classes of orientation values (Adaptation of: Lambrecht and Trautner, 2007)

Relative loss	Level	Classes of orientation values*						
		1	2	3	4	5	6	7
≤0.1%	I basic	0	0.01	0.1	0.5	1	5	10
≤0.5%	II middle	0	0.25	2.5	5	25	50	250
≤1%	III high	0	1	5	10	50	100	500

**Orientation values are divided into 7 classes, the surfaces NEN core areas are given in hectares (ha)* average annual daily traffic frequency in the range of 8,500-21,000 vehicles/day and prevailing winds with speed between 1.5-4.5m/s, the obtained results show that the predicted exceedance of the thresholds was detected up to the distance of between 6 and 110m away from the road edge (mean value of 50-60m), without calculating the cumulative effects. These results can represent a basis for determining the negative impacts of public roads, in case the effects of long-term exposure of habitats to traffic pollution are also taken into consideration, which is one of the requirements of the Appropriate Assessment. Considering the modelling results and using the above-mentioned references about sedimentation of emitted pollutants (according to which the minimum recorded relevant distance from the road is 100m), 50-60m and 100-110m can be used as referent values for determining the negative impact of traffic on habitats, depending on the habitat type and vehicle frequency. According to the aforementioned data, 50m represents the shortest distance up to which significant concentrations of pollutants were measured. Therefore, the planning of roads along habitats at a lesser distance would result in a loss of the affected segment over time. For roads with average annual daily traffic of 10,000 vehicles, greater distances (100-110m) have to be set up, depending on the habitat sensitivity. For example, in case of the roads with high traffic frequency next to sensitive habitat types (e.g. wetlands) basic value of distance should not be less than 100m and it should be possible to make more precise calculations by using additional impact factor (equation 1).

The selection of roads, for which data was collected, has been done on the available data from the documentation of PE 'Roads of Serbia' in the period of 2008-2012, in correlation with the 'Counting the Traffic on State Roads of the Republic of Serbia' reports. Based on the available data on average annual daily values for traffic frequency, the values for the average eight-year volume of traffic on certain sections inside and also within the impact zone of the protected area were obtained. Since no available data exist for particular roads, the periodically collected continuous seven-day traffic counts were used, which are the monitoring results of 'Road Center of Vojvodina' PLLC in the period of 2011-2012. The roads, on which traffic frequency was monitored, were classified into six classes according to the intensity of traffic (Table 2). According to the data from Table 2, almost half of the roads transecting the protected areas belong to class 2, with an

Table 2. Road classification

PA Classification		
Class	P (ha)	No. of PA
1	0-10	0
2	10-100	2
3	100-500	9
4	500-1,000	5
5	1,000-5,000	6
6	5,000-10,000	6
7	10,000 up	3
Total		31

Table 3. Classification of protected areas

Road classification		
Class	Traffic intensity	Number of roads
1	1,000-2,000	8
2	2,000-4,000	23
3	4,000-6,000	9
4	6,000-8,000	3
5	8,000-10,000	7
6	more than 10,000	1
Total		51

average annual daily traffic frequency of 2,000-4,000 vehicles (roads with a relatively low level of traffic load). However, in some cases (Straža Natural Monument, Table 4) the construction of such roads itself represents a significant threatening factor for protected area.

The data on the protected area borders and the natural values were acquired from the Electronic database of the Institute for Nature Conservation of Vojvodina Province. The core areas of the national ecological network (protected areas) were divided into seven classes based on their area size (Table 3). According to Table 3, the lowest number of roads (2) is transecting or passing next to the protected areas that have the smallest surface in the range of 10-100 ha (fragments of natural habitats). However, this does not mean that their endangerment is negligible, because Straža Natural Monument, where a significant habitat loss was recorded due to road construction (Table 4), belongs to this category. The protected areas whose borders are located more than 50 meters away from the existing state roads were excluded from the classification. Route sections of the roads were digitalised based on the available ortho-photo imagery and high resolution satellite images from Google Earth Pro programme. This service also provided the calculation of the data on the distance of roads from the borders of protected area, the location related to different parts of the PAs and also the length of the route inside the PAs and within the impact zone of the given area. The minimum values for road carriageway width (7m for main, and 6.5m for regional roads and roads transecting the protected areas) were used to calculate the absolute loss of habitats. Graphical presentation of impact areas was obtained by transferring geographic data from GIS applications onto a satellite layer (Google maps) by reprojection and conversion. The borders of the possible impact strips were obtained by geoprocessing the vector elements of the protected areas in shapefiles (*.shp), with a defined 50m buffer zone around a single vector (PA and road borders). Data obtained by projecting the impact areas have a high level of precision, because the borders of the PAs were used as a basis, which were determined by digitalising cadastral maps in scale 1:2500 in ArcGIS 10 software package.

The calculation of total relative habitat loss caused by road construction and usage is done by the following equations developed for the purposes of this assessment [1]:

$\Sigma Gr[\%] = (\Sigma Gu * 100) : P_{zp}$ [1]

$\Sigma Gu[ha] = Gi + \Sigma Gs$

$\Sigma Gs[ha] = G_{50} * d_u$

ΣGr = the total relative habitat loss (%)

P_{zp} = the surface of the protected area

ΣGu = total habitat loss caused by road construction and usage (ha)

Gi = habitat loss by road construction (ha)

ΣGs = total loss of habitat due to secondary effects caused by road usage

G_{50} = minimum value of habitat loss, calculated up to the distance of 50m from the road (ha)

d_u = additional impact factor on the protected area of a given road section

$d_u = f$ (traffic intensity on a given road section, road position in relation to the landscape, presence of endangered species, route interference with migratory corridors, habitat sensitivity on environmental impacts etc.)

For the purposes this article, the adopted value $d_u = 1$, then $\Sigma Gs[ha] = G_{50}$

RESULTS AND DISCUSSION

Results

Based on the analysis of maps obtained in this assessment, it was found that state roads are located in the vicinity of 22 protected areas and intersect the area of 12 out of 41 protected areas. The routes of 55 roads are located in the impact zones of protected areas. Relative habitat loss caused by the overlap with the network of state roads is shown in Table 4. Habitat loss based on the ratio of the road surface compared to the surface of Straža (NM) Natural Monument (0.67%) is classified into the group of 0.5-1%, which implicates a high level of risk. A 0.37% habitat loss in Titelski breg (SNR) Special Nature Reserve implies a middle level of risk (0.1-0.5%), while the rest of protected areas belong to the group with basic level of risk (0.1-0.5%). Considering the fact that the local road covers another 0.57% of Straža NM, the total area occupied by roads is 1.24%. The calculation results indicate that the existence of road surfaces already causes capacity exceeding on Straža NM, without the impact area (4.85%) taken into consideration. By adding those areas to the absolute habitat loss, the exceedance of capacity is determined on Titelski breg SNR (2.83%), while Fruška gora (NP) National Park (0.52%), Ludaško jezero SNR (0.60%) and Karaš-Nera (LEF) Landscape of Extraordinary Features (0.64%) are classified as areas with high level of risk.

Table 4. The relative habitat loss by overlapping roads and impact areas with protected areas

Protected area	Pzp (ha) *COV*	Road (old category)	Road (new category)	Traff. Intens. (av.day.yr.)	Ls-zp (m)	Ps (ha)	Gi (%)	P50 (ha)	G50zp (%)
Gornje	19604.99	R101:0778	II-107	3592	1000	0.65		5.00	
Podunavlje	*7*	M17.1:0373	IB-16	1998	5450	3.81	0.02	27.25	0.39
Fruška gora	25393.00	M18.1:0398	II-121	1743	3900	2.73		19.50	
	7	R116:1041	II-123	nad	3380	2.20		16.90	
		R130:1216	II-313	nad	8210	5.34		41.05	
		M21:0438	IB-21	9188	960	0.67	0.07	4.80	0.52
		M21:0439	IB-21	9188	4230	2.96		21.15	
		M21:0440	IB-21	9188	3710	2.60		18.55	
		M21:0441	IB-21	9188	1870	1.31		9.35	
Kovilj.-petrov. rit	5895.31 *6*	M22:0507	A-1	12767	2300	1.61	0.03	11.50	0.20
Jegrička	1193.19	R104:0870	II-112	nad	100	0.07		0.50	
	5	R104:0871	II-112	nad	40	0.03		0.20	
		M22:0501	A-1	5935	60	0.04		0.30	
		M22.1:0580	II-100	4573	90	0.06	0.05	0.45	0.41
		R120:1089	II-102	3607	130	0.08		0.65	
		R122:1127	II-114	2681	230	0.15		1.15	
		M7:0312	IB-12	7485	320	0.22		1.60	
Kamaraš	267.96	M22.1:0563	II-100	1732	10	0.01		0,05	
	3	M22:0493	A-1	5189	30	0.02	0.01	0.15	0.07
Ludaško	846.33	M22.1:0565	II-100	2366	600	0.42		3.00	
jezero	*4*	M22:0495	A-1	5229	420	0.29	0.08	2.10	0.60
Straža	67.61 *2*	M7.1:0333	IB-18	2658	650	0.46	0.67	3.25	4.85
Deliblat. peščara	34829.32 *7*	R115:1037	II-134	nad	6240	4.06	0.01	31.20	0.09
Rusanda	1159.98 *5*	R113:1021	II-116	2220	260	0.17	0.02	1.30	0.11
Karaš-Nera	1541.27 *5*	R115:1037	II-134	nad	1970	1.28	0.08	9.85	0.64
Ritovi d.Potisja	3010.67 *5*	M7:0312	IB-12	7485	260	0.18	<0.01	1.30	0.04
Titelski breg	496.00 *3*	R110:0992	II-129	2025	2810	1.83	0.37	14.05	2.83

Legend:
nad - no available data; Pzp - protected area surface; COV-classes of orientation values; Gi - habitat loss by road construction; P50 - the surface of the impact area calculated up to the distance of 50m from the road; Ls-zp - length of the road intersecting the protected area; Ps – threatened surface of protected area; G50zp - relative habitat loss caused by roads and their impact area

Total relative habitat loss is shown in Table 5. Apart from the road impact within the protected areas, it includes the impact areas located up to 50m away from the borders of PAs which are (to smaller or larger extent) overlapping with them. It is evident that capacity exceedance is occurring on Bagremara SNR (1.11%), Kamaraš (NaP) Nature Park (1.33%), Slano Kopovo SNR (2.43%) and Selevenjske pustare SNR (1.89%). An interesting fact is that the capacity exceedance on Slano Kopovo SNR and Selevenjske pustare SNR occurs only as a result of overlapping of road impact areas, whose routes are located along the border of the protected areas. Based on total relative habitat loss Karaš-Nera LEF (0.94%), Fruška gora NP (0.65%) and Jegrička NaP (0.6%) are classified as areas with high level of risk.

Table 5. The total relative habitat loss

Protected area	Pzp (ha) *COV*	Road (old category)	Traff. Intens. (av.day.yr.)	Ps (ha)	Gi (%)	P50 (ha)	G50zp (%)	Pou50 (ha)	Gou50 (%)	ΣGr (%)
Gornje	19604.99	M17.1:0373	1998	3.81		27.25		osr		
Podunavlje	*7*	R101:0778	3592	0.65	0.02	5.00	0.39	1.93	<0.01	0.41
Fruška gora	25393.00 *7*	M18.1:0398	1743	2.73		19.50		0.80		
		M18:0394	2089	osr		osr		9.50		
		R116:1041	nad	2.20		16.90		osr		
		R107:0932	2194	osr	0.07	osr	0.52	0.70	0.06	0.65
		R130:1216	nad	5.34		41.05		5.11		
		M21:0438	9188	0.67		4.80		0.65		
		M21:0439	9188	2.96		21.10				
		M21:0440	9188	2.60		18.55		osr		
		M21:0441	9188	1.31		9.35				
Kovilj.-petrov. rit	5895.31 *6*	M22:0507	12767	1.61	0.20	11.50	0.20	osr		0.40
Jegrička	1193.19 *5*	R104:0870	nad	0.07		0.50		0.70		
		R104:0871	nad	0.03		0.20				
		M22:0501	5935	0.04		0.30				
		M22.1:0580	4573	0.06	0.05	0.45	0.41	osr	0.14	0.60
		R120:1089	3607	0.08		0.65				
		R122:1127	2681	0.15		1.15				
		M7:0312	7485	0.22		1.60				
Kamaraš	267.96	M22.1:0563	1732	0.01		0.05		2.02		
	3	M22:0493	5189	0.02	0.01	0.15	0.07	1.32	1.25	1.33
Ludaško jezero	846.33 *4*	M22.1:0565	2366	0.42		3.00		4.65		
		M22.1:0566	8058	osr	0.08	osr	0.60	0.25	0.58	1.26
		M22:0495	5229	0.29		2.10		osr		
Obedska bara	9820.00 *6*	R121:1112	nad	osr	*	osr	*	28.45	0.29	0.29
Slano kopovo	976.45	R114:1032	nad					12.15		
	4	M3:0170	3366	osr	*	osr	*	11.55	2.43	2.43
Straža	67.61 *2*	M7.1:0333	2658	0.46	0.67	3.25	4.85	2.45	3.62	9.15
Karađorđevo	4184.24 *5*	M18:0390	1913	osr	*	osr	*	1.80	0.04	0.04
Bagremara	117.58 *3*	M18:0391	2951	osr	*	osr	*	1.30	1.11	1.11
Deliblat. peščara	34829.32 *7*	R115:1037	nad	4.06	0.01	31.20	0.09	1.95	<0.01	0.10
Selevenjske	677.04	M22:0494	5101					5.30		
pustare	*4*	M22.1:0565	8058	osr	*	osr	*	12.25	1.89	1.89
Carska bara	4726.00 *5*	R110:0992	2509	osr		osr		19.45	0.41	0.41
Palić	712.36	M22.1:0568	nad					2.65		
	4	M24:0644	nad	osr	*	osr	*	3.00	0.79	0.79
Rusanda	1159.98 *5*	R113:1021	2220	0.17	0.02	1.30	0.11	0.95	0.08	0.21
Karaš-Nera	1541.27	R115.1:1039	nad	osr		osr		osr		
	5	R115:1037	nad	1.28	0.08	9.85	0.64	3.45	0.22	0.94
Ritovi d.Potisja	3010.67 *5*	M7:0312	7485	0.18	<0.01	1.30	0.04	3.45	0.12	0.20
Titelski breg	496.00 *3*	R110:0992	2025	1.83	0.37	14.05	2.83	5.00	1.01	4.21

Legend:
osr - outside of the scope of research; nad - no available data; Pzp - protected area surface; COV-classes of orientation values; Ps - threatened surface of protected area; Gi - habitat loss by road construction; P50 - the surface of the impact area calculated up to the distance of 50m from the road on protected area; G50zp - relative habitat loss caused by roads on protected area and their impact area; Pou50 - the surface of impact area of roads outside of the protected area; Gou50 - relative habitat loss caused by impact area of roads outside of the protected area;
Gr - the total relative habitat loss

Total relative habitat loss is shown in Table 5. Apart from the road impact within the protected areas, it includes the impact areas located up to 50m away from the borders of PAs which are (to smaller or larger extent) overlapping with them. It is evident that capacity exceedance is occurring on Bagremara SNR (1.11%), Kamaraš (NaP) Nature Park (1.33%), Slano Kopovo SNR (2.43%) and Selevenjske pustare SNR (1.89%). An interesting fact is that the capacity exceedance on Slano Kopovo SNR and Selevenjske pustare SNR occurs only as a result of overlapping of road impact areas, whose routes are located along the border of the protected areas. Based on total relative habitat loss Karaš-Nera LEF (0.94%), Fruška gora NP (0.65%) and Jegrička NaP (0.6%) are classified as areas with high level of risk.

Comparing the data from Table 3 (COV-classes of orientation values) with the data from Tables 4 and 5, a significant difference in the number of threatened core areas of the national ecological network within certain classes could be observed. The difference between the total number of potentially threatened areas (Table 3) and the analysed areas (Tables 4 and 5) is related to the threatened parts of habitats due to the different position of the roads compared to the borders of the area (the maximum considered distance is 50m). Along the one-third of the total core areas belonging to the classes 3 and 6, roads were registered at the distance up to 50m (Tables 3 and 5), while at the core areas of class 7 a significant potential impact exists from all of the three recorded roads (Tables 3, 4 and 5). Compared with the total of 31 (Table 3), more than a third of the core areas (12) are threatened by the direct road transecting of habitats (Table 4). While analysing the core areas from class 3, only two (Table 4) out of the total of 9 areas (Table 3) are threatened by the direct transect. It is a significant fact considering that the size of the core areas of class 3 is quite small (100-500 ha), therefore a larger number of roads transect could cause significant habitat loss.

Discussion

The application of the approach by Lambrecht and Trautner considers only the habitat loss by direct occupation of the area. This article goes a step further attempting to consider the secondary negative effects of traffic resulting from pollutant sedimentation. For the analysis, only the minimum values of the distance from the roads were used, for which the probability of loss of the threatened part of habitat is near one, due to deterioration of environmental quality. The value of 1% (as the maximum acceptable habitat loss) should be considered for the area of Vojvodina, because the remaining fragments of natural habitats under the current conditions are barely enough to provide the proper functionality of the ecological network.

Research results regarding protected areas are the basis for determining the possibility of road construction in relation to the total capacity of the area. In addition to area capacity, restrictions on road construction and the usage of roads depend on the traffic volume of a given road section, road position in relation to habitat types and landscape elements, the existence of endangered animal species on the area of direct impact, route interference with migratory corridors, habitat sensitivity on environmental impacts, etc. In such cases, area protection measures may include speed limitation, construction of noise barriers, planting of protective vegetation (in a way to exclude the disruption of the overtaking visibility of roads) as well as application of other planning and construction solutions that contribute to the habitats and species protection, while maintaining the security of traffic functioning. However, when the capacity of a protected area is exceeded, or a habitat of a particularly endangered species exists nearby, it is necessary to find an alternative solution for the design of the road outside of the protected area.

The analysis of the satellite images indicates that the area between roads and protected areas is mainly covered by arable land. In cases where the sections of roads are in the vicinity of the protected area, it is necessary to consider the possibility of establishing shelterbelts on a safe distance, away from the road corridor. In addition to their role in noise mitigation, decrease in pollutants concentration and wind protection, complex structured shelterbelts (with a specific ratio of grass and shrub vegetation), may represent habitats to species of cultural landscapes, and can have the role of ecological corridors too.

When planting of high vegetation (tree plantation) is prohibited due to the ecological features of the landscape (e.g. steppes or meadows), compliance with the recommended distances from the borders of protected areas is essential. The construction of new roads in the impact zones of protected areas requires the establishment of cooperation between the sectors of transport, agriculture, forestry and nature conservation. It is necessary to determine the areas needed for the establishment of shelterbelts, by buying land from private owners or interchanging land in private and public ownership. A systematic approach is needed in the process of spatial planning to integrate the goals of natural values preservation.

CONCLUSIONS

The aim of this article is to show that even with a minimalistic approach (using the smallest values of the parameters related to road width and critical distance from the habitat), the vulnerability of certain core areas of the national ecological network is evident. For a detailed analysis of losses for each given habitat type, a more precise data will be used related to the subject of this research. This includes information on the sensitivity of habitat on different disturbances, landscape elements in the immediate vicinity, the occupation area of the road infrastructure (width of road area, related facilities, etc.). When assessing the impacts on species, it is necessary to use data on their sensitivity to noise, vibration, lighting, etc. In the process of constructing new roads, the construction of ancillary facilities, retention ponds, borrow pits etc. must also be taken into consideration. The application of principles from this article in nature conservation and spatial planning practice could help in a more effective arrangement of road network elements in accordance with the sensitivity and capacity of the area. The result of analysis obtained by overlaying the road infrastructure and protected areas can be used for determining the possibilities of road construction and operation related to the total capacity of the area, characteristics of natural habitats and traffic. Upon the valorisation of future core areas of the Natura 2000 network and the designation of the Natura 2000 in Serbia, classes of orientation values could be changed. Taking into account that habitat type approach is one of the key elements when dealing with the Natura 2000 network, the use of relative habitat loss and other criteria given in the article should be further tested and developed.

When the application of the conservation measures cannot prevent habitat degradation, threats to endangered species and ecosystem destruction, it is necessary to find an alternative solution for designing road routes at the appropriate distance from the areas under protection. One of the key factors of sustainable development is the integral approach in land use along with the consideration of all alternative options. A detailed traffic analysis for assessing the impact on a protected area of a given road section that lacks available data requires the establishment of continuous monitoring of traffic intensity on the sections which are located in the impact zone of the areas inside the national ecological network. Preparation of projects in this field could represent the basis for the development of habitat assessment methodology, needed for the Appropriate Assessment of building construction or any other works and activities in the impact zone on protected areas. Construction of new roads in the impact zone of protected areas also requires the establishment of cooperation between the sectors of transport, agriculture, forestry and nature conservation. A systematic approach to this problem represents a way for the implementation of the existing strategic planning documents and the current legislation (that deals with the protection of natural values) into the plans of each given sector.

References

Aresco, M.J. (2005) The Effect of Sex-Specific Terrestrial Movements and Roads on the Sex Ratio of Freshwater Turtles. *Biological Conservation* 123, pp. 37-44.

Balestrieri, M. (2013) Contested Landscapes: Conflicts of Interests and Controversies in Planning and Using Space, *Spatium* 29, pp. 53-58.

Beckerman, B., Jerrett, M., Brook, J.R., Verma, D.K., Arain, M.A., Finkelstein, M.M. (2008) Correlation of Nitrogen Dioxide with Other Traffic Pollutants Near a Major Expressway. *Atmospheric Environment,* 42, pp. 275-290.

Bhattacharya, M., Primack, R.B., Gerwein, J. (2003) Are Roads and Railroads Barriers to Bumblebee Movement in a Temperate Suburban Conservation Area. *Biological Conservation,* 109, pp. 37-45.

Brugge D, Durant JL, Rioux C. (2007) Near-Highway Pollutants in Motor Vehicle Exhaust: A Review of Epidemiologic Evidence of Cardiac and Pulmonary Health Risks. *Environment Health*, 6:23.

Clarke, G.P., White, P.C.L., Harris, S. (1998) Effects of Roads on Badger *Meles meles* Populations in South-West England. *Biological Conservation,* 86, pp. 117-124.

Clevenger, A. P., Chruszcz, B., Gunson, K.E. (2003) Spatial Patterns and Factors Influencing Small Vertebrate Fauna Roadkill Aggregations. *Biological Conservation,* 109, pp. 15-26.

Coffin, A. W. (2007) From Roadkill to Road Ecology: A Review of the Ecological Effects of Roads. *Journal of Transport Geography,* 15, pp. 396-406.

Ćirović, D., Kureljeušić, B. (2012) Analiza mortaliteta evropskog dabra (*Castor fiber* L. 1758) na području Zasavice. *in* Simić S. (ed.) *Naučno-stručni skup Zasavica 2012*, pp. 215-225.

Develey, P.F., Stouffer, P.C. (2001) Effects of Roads on Movements by Understory Birds in Mixed-Species Flocks in Central Amazonian Brazil, Conservation *Biology* 15, pp. 1416-1422.

EEA (2010) The European Environment — State and Outlook 2010: Assessment of Global Megatrends, *European Environment Agency*.

Farmer, A.M. (1993) The Effects of Dust on Vegetation – A Review, *Environmental Pollution,* 79, pp. 63-75.

Forman, R.T.T., Deblinger, R.D. (2000) The Ecological Road-Effect Zone of a Massachusetts (USA) Suburban Highway, *Conservation Biology*, 14, pp.36-46.

Forman, R.T.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Chutshall, C.D., Dale, V.H. (2003) *Road Ecology. Science and Solutions*. Washington: *Island Press.*

Gilbert NL, Woodhouse S, Stieb DM, Brook JR. (2003) Ambient Nitrogen Dioxide and Distance from a Major Highway, *Science of Total Environment,* 312, pp. 43-6.

Godefroid, S., Koedam, N. (2004) The Impact of Forest Paths upon Adjacent Vegetation: Effects of the Path Surfacing Material on the Species Composition and Soil Compaction, *Biological Conservation,* 119, pp. 405–419.

Hagler, G.S.W., Baldauf, R.W., Thoma, E.D., Long, T.R., Snow, R.F., Kinsey, J.S., Oudejans, L., Gullett, B.K. (2009) Ultrafine Particles Near a Major Roadway in Raleigh, North Carolina: Downwind Attenuation and Correlation with Traffic Related Pollutants. *Atmospheric Environment,* 43, pp. 1229-1234.

Hannah, L., Midgley, G.F., Lovejoy, T., Bond, W.J., Bush, M., Lowett, J.C., Scott, D. & Woodward, F.I. (2002) Conservation of Biodiversity in a Changing Climate. *Conservation Biology,* 16/1, pp. 264-268

Hawbaker, T.J., Radeloff, V.C. (2004) Roads and Landscape Pattern in Northern Wisconsin Based on a Comparison of Four Road Data Sources. *Conservation Biology,* 18, pp.1233-1244.

Health Effects Institute (HEI) (2010) *Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects*. Final Version of Special Report No. 17. Boston, Mass.: Health Effects Institute.

Hels, T., Buchwald, E. (2001) The Effect of Road Kills on Amphibian Populations, *Biological Conservation,* 99, pp. 331-340.

Hicks,W.K., Whitfield, C.P., Bealey, W.J. & Sutton M.A. (2011) Nitrogen Deposition and "Natura 2000" - Science and Practice in Determining Environmental Impacts, *Workshop Proceedings*, COST729/Nine/ESF/CCW/JNCC/SEI.

Hitchins, J., Morawska, L., Wolff, R., Gilbert, D. (2000) Concentrations of Submicrometre Particles from Vehicle Emissions Near Major Road. *Atmospheric Environment,* 34, pp.51-59.

Huijser, M., Bergers, P.J.M. (2000) The Effect of Roads and Traffic on Hedgehog (*Erinaceus europaeus*) Populations. *Biological Conservation,* 95, pp. 111-116.

Jaarsma, C.F., van Langevelde, F., Botma, H. (2006) Flattened Fauna and Mitigation: Traffic Victims Related to Road, Traffic, Vehicle, and Species Characteristics. Transportation Research. Part D. 11. *Science Direct*. pp. 264-276.

Kicošev, V. & Szabados, K. (2007). Integracije zaštite prirode u perspektive održivog razvoja u Srbiji. *Ecologica*. Beograd: Naučno-stručno društvo za zaštitu životne sredine Srbije, pp.76-80.

Kicošev, V., Radosavljević, M., Kovačević, N. & Đukić, S. (2011) Uloga analize zainteresovanih strana u održivom korišćenju budućih zaštićenih područja na primeru „Rusande" i „Okanj bare". *Zaštita prirode*, 61-2, Beograd: Zavod za zaštitu prirode Srbije, pp.129-146.

Kicošev, V., Mesaroš, M., Veselinović, D., Szabados, K. (2013) Uspostavljanje zona unutar zaštitnih pojaseva prirodnih dobara u funkciji prilagođavanja na klimatske promene. *Ecologica*, 70, Beograd: Naučno-stručno društvo za zaštitu životne sredine Srbije, pp. 181-187.

Lambrecht, H., Trautner, J. (2007) Fachinformationssystem und Fachkonventionen zur Bestimmung der Erheblichkeit im Rahmen der FFH-VP – Endbericht zum Teil Fachkonventionen, Schlussstand Juni 2007. – FuE-Vorhaben im Rahmen des Umweltforschungsplanes des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit im Auftrag des Bundesamtes für Naturschutz - FKZ 804 82 004 (unter Mitarb. von K. Kockelke, R. Steiner, R. Brinkmann, D. Bernotat, E. Gassner & G. Kaule).

Lankester, K., Van Apeldoorn, R., Meelis, E., Verboom, J. (1991) Management Perspectives for Populations of the Eurasian Badger (*Meles meles*) in a Fragmented Landscape, *Journal of Applied Ecology,* 28, pp. 561-573.

Laurance, W.F., Williamson, G.B. (2001) Positive Feedbacks among Forest Fragmentation, Drought, and Climate Change in the Amazon. *Conservation Biology,* 15, pp. 1529-1535.

Lisec, A., Drobne, S. (2009) The Influence of Protected Natural and Cultural Heritage on Land Management/Market – The Case of Slovenian Natural Protected Areas, *Spatium,* 20, pp. 41-48.

Mumme, L.R., Schoech, J.S., Woolfenden, E.G., Fitzpatrick, W.J. (2000) Life and Death in the Fast Lane: Demographic Consequences of Roadmortality in the Florida Scrub-Jay. *Conservation Biology,* 14, pp. 501-512.

Noss, R.F. (2001) Beyond Kyoto: Forest Management in a Time of Rapid Climate Change, *Conservation Biology,* 15/3, pp. 578-590.

Oxley, D.J., Fenton, M.B., Carmody, G.R. (1974) Effects of Roads on Populations of Small Mammals. *Journal of Applied Ecology* 11, pp. 51-59.

Palominoa, D., Carrascal, L.M. (2007) Threshold Distances to Nearby Cities and Roads Influence the Bird Community of a Mosaic Landscape, *Biological Conservation* ,140, pp. 100-109.

Pantelić, N. (1995) *Problem gaženja vodozemaca i gmizavaca na asfaltnom putu uz Obedsku baru*. Edicija Povratak ibisa – sveska 1. Povratak Obedskoj bari. Beograd: Mladi istraživači Srbije.

Reponen, T., Grinshpun, S.A., Trakumas, S., Martuzevicius, D., Wang, Z.M., Le Masters, G., Lockey, J., E., Biswas, P. (2003) Concentration Gradient Patterns of Aerosol Particles Near Interstate Highways in the Greater Cincinnati Airshed. *Journal of Environment Monitoring,* 5, pp. 557-562.

Roorda-Knape, M.C., Janssen, N.A.H., de Hartog, J.J., van Vliet P.N.H., Harssema, H., Brunekreef, B. (1998) Air Pollution from Traffic in City Districts Major Motorways. *Atmospheric Environment,* 32, pp. 1921-1930.

Szabados, K.,Kicošev, V. (2006) Planiranje infrastrukture na prirodnim dobrima u funkciji održivog turizma, *Ecologica* 12, Beograd: Naučno-stručno društvo za zaštitu životne sredine Srbije, pp. 71-75.

Szabados, K., Panjković B. (ured.) (2009) *Uspostavljanje ekološke mreže u AP Vojvodini – pregled stanja, analiza i mogućnosti*, Izveštaj. Novi Sad: Zavod za zaštitu prirode Srbije.

Seiler, A., Folkeson, L. (eds.) (2006) COST 341: Effects of Infrastructure on Nature: Habitat Loss. VTI Report 530A. Linköping: VTI.

Stojnić, N. (2004) *Dva slučaja stradanja orla krstaša Aquila heliaca. Ciconia, 13*. Novi Sad: Društvo za zaštitu i proučavanje ptica Vojvodine, pp. 210-211.

Suzuki, N., Brauer, M. (2012) *Develop With Care 2012: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Supporting Information - Air Quality*. Vancouver: British Columbia Ministry of Environment, University of British Columbia.

Tiitta, P., Raunemaa, T., Tissari, J., Yli_Tuomi, T., Leskinen, A., Kukkonen, J., Harkönen, J., Karppinen, A. (2002) Measurements and Modelling of PM_{25} Concentrations Near Major Road in Kuopio, Finland. *Atmospheric Environment,* 36, pp.4057-4068.

Trombulak, S. C., Frissel, C. A. (2000) Rewiew of Ecological Effects of Roads on Terrestrial and Aquatic Communnities, *Conservation Biology,* 14/1, pp.18-30.

Van Langevelde, F., van Dooremalen, C., Jaarsma, C.F. (2008) Traffic Mortality and the Role of Minor Roads. *Jurnal of Environmental Management*, 90, pp. 660-667.

Vermeulen, H.J.W. (1994) Corridor Function of a Road Verge for Dispersal of Stenotopic Heathland Ground Beetles (Carabidae). Biological Conservation, 3, pp. 339-349.

Wilkins, K.T., Schmidly, D.J., 1980. Highway Mortality of Vertebrates in Southeastern Texas. *Texas Journal of Science,* 4, pp. 343-350.

Willard, B.E., Marr, J.W. (1971) Recovery of Alpine Tundra Under Protection After Damage by Human Activities in the Rocky Mountains of Colorado, *Biological Conservation* 3, pp. 181-190.

Zhou, Y., & Levy, J. I. (2007) Factors Influencing the Spatial Extent of Mobile Source Air Pollution Impacts: A Meta-Analysis. *BMC Public Health*, 7, 89.

Zhu YF, Hinds WC, 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, pp. 1032-1042.

Received February 2014; accepted in revised form May 2014