USAGE OF GIS IN WILDLIFE PASSAGE PLANNING IN ESTONIA

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Abstract

Wildlife passages - underpasses or overpasses designed specifically for wild animals - are a means to mitigate effects of fragmentation of habitats. There are several other possibilities to avoid traffic accidents with wild animals. All these measures and constructions have to be foreseen in planning new road or road section. How there is possible to use GIS in that process, particularly in case of quite young independent country as Estonia, is a topic of that paper. Main consider is given to planning process of new section of national road T2 between two biggest towns in Estonia Tallinn and Tartu that will cross main forest passages used by large animals for internal migration. Also cross-sections of road and ecological networks are reflected.

Introduction

Estonia has notable diversity of natural and semi-natural habitats that are still remained at the quality which is sufficient for their protection. Also, quite a number of species inhabit in these diverse habitats. At the same time there is a big risk for quick destruction and fragmentation of these habitats and due to that also species diversity, because of enlargement of the infrastructure in the conditions of quickly developing economy. Therefore strong need for environmentally friendly planning of the infrastructure has risen into agenda.

Current paper presents relevant Estonian fragmentation statistics given through the cross-section analysis of road and ecological networks as well as wildlife passage planning at the national road Tallinn-Tartu (T 2). Work was planned in the Institute of Geography in University of Tartu, after first studies made for State Road Agency in order to find out the best possible corridor of the road under discussion. When possible corridor of new road section was set up, State Road Agency asked Ministry of Environment to point out locations for approximately eight underpasses for game animals on that section. At the same time started current study in University of Tartu, where I started my master degree studies, being at the same time employee in Estonian Environment Information Centre, which is executive body near the Ministry of Environment.

After screening relevant literature and data, and scoping needs for wildlife passage planning in Estonia, it was obvious that special study is needed for locating cross points of road and ecological network for proper set up of precise underpass locations and their optimal construction types. Therefore, was current study divided into three stages: 1. GIS analysis, basing CORINE Land Cover project and using newest layers for nature conservation and infrastructure; 2. Gathering relevant statistics about car accidents with animals from all possible sources, pointing up locations of these accidents; 3. Gathering information from hunters about their pointed locations for possible underpasses on the new section of road T2 (Tallinn-Tartu).

In that stage of the study only large vertebrates are focussed on, because the big difference of passage constructions for large and small vertebrates needs also slightly different approach in planning process.

Study Area

The republic of Estonia is situating at the eastern coast of the Baltic sea having common borderline with Finland in north, Sweden in west, Latvia in south and Russia in east. Total area of Estonia according the Statistical Office of Estonia is 45 227 km^2 and resident population 1 462 130 inhabitants (1 015 369 in 47 towns - 420 470 in Tallinn and 101 901 in Tartu). Road network in Estonia according the data of State Road Agency is 44 182 km long, having 16 430 km public roads and only 8366 km with a pavement. It makes total mean road density to be 0,977 km/km^2 and mean density of paved roads 0,185 km/km^2. Mean density of public roads is 0,363 km/km^2. Number of cars in Estonia is 537 877, which makes 372 cars per 1000 inhabitants. Intensity of traffic on bigger public roads varies from 720-15790 cars per section in 24 hours that makes mean of 8255 cars. Anyhow there is mostly intensity between 3000-6000 cars per section outside of Tallinn area. From the other hand the statistics about Estonian nature shows well-forested country. There is 20 155 km^2 forested land in Estonia, which is 47,5 % of total country area. In these largely natural forests are living approximately 29 000 roe deers *(Capreolus capreolus)*, 7700 moose *(Alces alces)*, 10 300 wild boars *(Sus scrofa)*, 1200 lynxes *(Felis lynx)*, 600 brown bears *(Ursus arctos)* and 300 wolves *(Canis lupus)*. Large game animals are concentrated mainly at the mid-Estonian forests (Table 1), having internal migration passages from NE-Estonia to SW-Estonia and also from mid-Estonia to NW-Estonian forest and bog areas. Also, distribution scheme of large carnivores is showing strong concentration in continental forested areas. Despite these distribution facts still no any other measures than traffic marks showing possible ungulates appearance on roads were taken.

Table 1. Population density of the moose on monitoring areas in Estonia (Randveer, 1999).

Monitoring area	**Population density of moose (ind. per 1000 ha)**		
	1996	1997	1998
Western part of Lahemaa National Park	6,7	4,1	5,3
Eastern part of Lahemaa National Park	5,3	2,1	4,2
Forest District Laeva	7,1	7,2	8,1
Forest District Triigi	1,3	1,8	3,4
Forest District Türi	0,3	1,6	1,3
Forest District Vihterpalu	**16,3**	**10,8**	**12,7**
Forest District Kihelkonna	10,6	9,0	5,1

Forest of Järvselja	-	4,4	6,1
Forest District Väätsa	-	**11,6**	-

Case study for passage planning was carried out on ca 74 km long and 500 m wide corridor of planned new section of national road T2 between two biggest towns in Estonia - Tallinn and Tartu (Fig. 1). Section is connecting administrative units Kose and Mäo and will cross main forest corridor containing several large vertebrate trails. Section also crosses forest district Väätsa with high concentration of ungulates, specially moose (Table 1.).

Methods

For background layer CORINE Land Cover database was used. CORINE Land Cover project in Estonia was compiled at 1996-1998. During the project Estonian digital database was completed on the basis of common European methodology. The aim of the project was natural resource mapping, done by using remote sensing. Land cover essentially concerns the nature of features (forest, crop, water body, bare rock etc.). Working scale was 1:100 000; data from Landsat MSS/TM sensors were used; the satellite data by means of photo interpretation of false-colour images was analysed; unit area was clearly characterised; the size of the smallest unit mapped was 20 ha and land cover nomenclature was hierarchically structured in three levels into 44 land cover classes. CORINE Land Cover project was part of European Union CORINE program, which was implemented in EU member states in 1985-1990. Since 1991, the CORINE databases are preserved and processed by European Environment Agency. The CORINE databases in Central and Eastern-European countries, incl. Estonia, were completed in 1995-1998 with the support of EU Phare program (Meiner, 1999)

On the background of land cover working layers of road network, river network, nature conservation areas, protected parks and specially road T2 were created with programme ARC/INFO and afterwards with ARCView. Possible ecological network was initiated as line connecting nature conservation areas through main forested areas were possible or through most natural habitats. Cross sections of that rough econet line and main roads were detected as possible conflict points between human created infrastructure and wildlife trails. Locations of these conflict points were estimated on main roads by kilometres. Comparison of these locations with animal accident statistics was done (Table 2). Also intensity of traffic on these possible conflict points was taken into account.

New section of national road T2 was digitized basing on a road corridor scheme on paper created by State Road Agency. Separately 500 and 100 wide buffer zones were initiated for both T2 and its new section. For new section of road T2 that crosses two counties, hunters from both counties were questioned to point possible underpass places for large vertebrates, taking into account main trails of animals. Comparison between information got from hunters and taken from GIS analysis was done and possible underpass locations marked on a separate digital layer. Also prioritisation of these underpass locations was done (Table 3).

At the second stage of a current study special field-works are planned to carry on twice (firstly in autumn and secondly in winter) in the study area: to check cross points of wildlife passages and new road corridor and mark their location with GPS on field, comparing these after with possible ones set up by using GIS analysis. Also, most optimal construction types of underpasses must be chosen for every location.

Results

GIS analysis of main ecological network and road network gave 50 possible conflict points on bigger roads (Table 2). Locations of these conflict points were compared with relevant statistical data and after combining them, a possible conflict location map was created (Fig2).

Table 2. Comparison of locations for possible conflict points with traffic and large vertebrates and actual statistics about game accidents on 10 bigger road sections in Estonia.

Road sections	**Locations of possible conflict, dist. from bigger town (km)**	**Locations of game accidents**
Tallinn-Haapsalu	10, **25**, 47, 70, **75**	**28**, 38, **74**, 94*
Tallinn-Pärnu	10, **30**, 45, 70, 90, 110	18, 20, 21, 22, **30**, **31**, 36, 40*
Tallinn-Tartu	28, 60, **65**, 105, 130, 145, **170**	**69**, 70, 71, 82, 83** 7, 9, 12, 18, 20, 23, 39, 55, **67**, **69**, 70, 82, 83, 124, **166*****
Tallinn-Narva	**30**, **50**, **70**, 110, 140, 165, 185	26, 27, **30**, 43, **49**, **50**, **71***
Tartu-Narva	30, 45, 95, 110	no data
Tartu-Valga	20, 35, 65	no data
Tartu-Luhamaa	20, 50, **80**, 90, 110	4, 27, 43, 55, 57, 77, **79*****
Pärnu-Valga	25, 40, 50, 80, 90	no data
Pärnu-Rakvere	5, 10, 30, 55, 85, 105, 140	no data
Pärnu-Ikla	65	no data

sources: * Mardiste, 1992; ** Randveer, 1999; ***State Road Agency, 1999

For special case study with national road T2 and its new planned section, also buffering zones both 100m and 500m wide around the road were taken into account. After combining data received from local hunters, from previous studies made and taken from statistics appeared 34 possible locations for wildlife underpasses in the section from Tallinn to Mäo and 25 of them appearing at new section of the road (Table 3). As the State Road Agency

informed their ability to built only eight underpasses, the prioritisation was done on the bases of statistics and hunters preferences, that ended to following selection:

1. Underpass or bridge over wildlife trails between 66-69 km;
2. Underpass between 60-62 km of old T2;
3. Underpass between 58-60 km of new section of T2;
4. Underpass with a stream between 52-53 km or extended bridge of Pirita River between 55-56 km;
5. Underpass with road and ditch between 45-49 km;
6. Underpass with road between 42-43 km of new section of T2;
7. Underpass between 43-44 km of old T2;
8. Underpass between 76-79 km or extended bridge of Pärnu River;
9. Underpass between 84-85 km;
10. Underpass or bridge over trails of elks between 66-67 km of old T2.

Table 3. All proposed wildlife passage locations and structures for the national road T2 section between Tallinn and Mäo and traffic intensity on these locations.

Nr.	**Dist. From Tallinn**	**Structure type (width of mouth)**	**Traffic intensity (cars per section in 24 hours, both ways)**	
			1998	**2010 (planned)**
1	8-9 km		9660	13500
2	18-19 km		7280	9300
3	23-24 km		6420	7800
4	28-29 km	road bridge over wildlife trails	6420	7800
5	29,6 km	extended bridge of Pirita River (50m)	6420	7800
6	30,8 km	underpass (40m)	6420	7800
7	34,1 km	road bridge over wildlife trails	6420	7800
8	34,5 km	underpass+stream (40m)	6420	7800
9	36,3 km	extended bridge (40m)	6420	7800
10	40,5 km	underpass (40m)	4710	6300
11	42,6-43 km	road bridge over wildlife trails	4710	6300
12	45-46 km	ditch+underpass	4710	6300
13	46,8 km	ditch+underpass (40m)	4710	6300
14	47,3 km	road+underpass	4710	6300
15	47,7 km	stream+underpass (40m)	4710	6300
16	49 km	road+underpass	4710	6300
17	**52,9 km**	**stream+underpass (40m)**	**4710**	6300
18	**53 km**	**road bridge over wildlife trails**	**4710**	6300
19	**55,4 km**	**extended bridge of Pirita river (90m)**	**4710**	6300
20	**55,5 km**	**river+road+underpass**	**4710**	6300
21	**57,6 km**	**stream+underpass (40m)**	**4710**	6300
22	**58 km**	**ditch+underpass**	**4710**	6300
23	**59,4 km (old road)**	**underpass (carnivores)**	**4710**	6300
24	**59-60 km**	**ditch+underpass**	**4710**	6300

25	**61,5 km (old road)**	**underpass**	**4710**	6300
26	**66,5 km (old road)**	**road bridge over wildlife trails**	**4710**	6300
27	**66,5 km**	**extended bridge of Reopalu river (90m)**	**4710**	6300
28	**68,3 km**	**ditch+road+underpass (40m)**	**4710**	6300
29	**69,7 km**	**ditch+road+underpass (40m)**	**4710**	6300
30	**71,5 km (old road)**	**underpass**	**4710**	6300
31	76,1 km	underpass (40m)	4710	6300
32	77 km (old road)	underpass (foxes and elks)	4710	6300
32	78,3 km	extended bridge of Pärnu river (60m)	4900	7500
33	82,4 km	extended bridge of Vodja river (40m)	4900	7500
34	90 km (old road)	underpass (carnivores and ungulates)	5640	7800

Discussion and Conclusions

During the study new approach of ecological network for Estonia was created connecting nature conservation areas along natural areas. Also first whole country covering digitized database - CORINE Land Cover was used and successfully. Therefore the first stage of the study should be taken as successful and following conclusions should be drawn up:

1. GIS analysis for detection of possible traffic and wildlife conflict-points seems to be very useful, having enough detailed background data. For current study the spatial preciseness of 20 ha was enough to get countrywide picture about most possible conflict points (50) on bigger roads. Still this is only first step towards detailed planning of wildlife passages, as it just points areas where most concentrated wildlife trails must be detected with fieldwork.

2. For national road T2 (Tallinn-Tartu), there are pointed possible underpass locations with preciseness of one kilometre, that still is not enough for starting to build up eight needed underpasses. Anyway there was detected good correlation between done GIS analysis and information got by questioning local hunters. Locations for possible underpasses on new road section are pointed much more precisely than countrywide analysis and is enough for detailed location detecting with fieldwork on next stage of overall study.

References Cited

Mardiste, M. 1992. Traffic accidents with animals. Eesti Loodus 5: 290-295.
Meiner, A. edited by. 1999. Land Cover of Estonia. Implementation of CORINE Land Cover project in Estonia. Tallinn, 133p.
Randveer, T. 1999. Monitoring of ungulates. Report of year 1998. Estonian Naturalists Society, Tartu, 12p.

Figure 1. Overview of the case study area on new section of road T2.

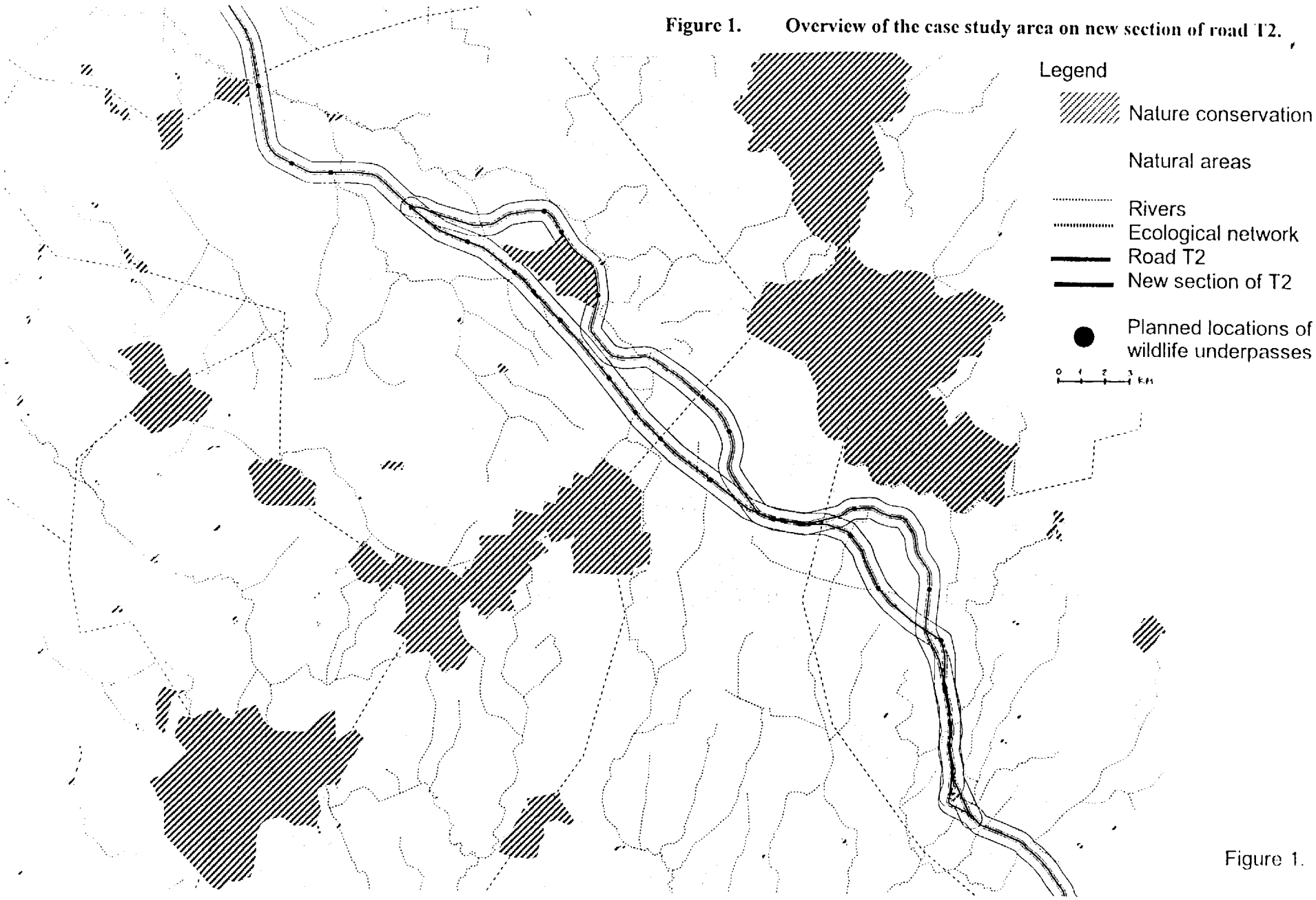

Figure 1.

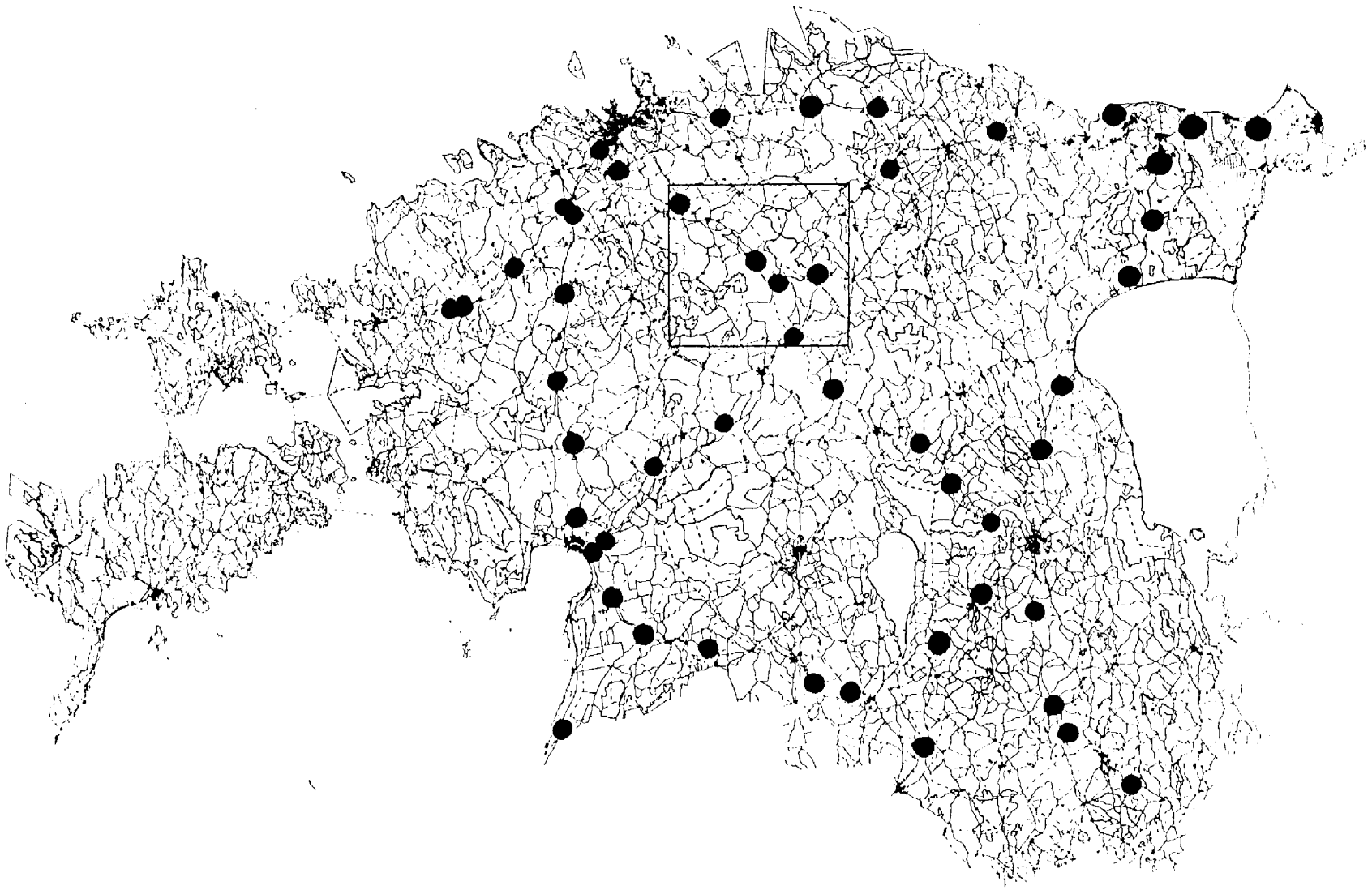

Figure 2. **Possible conflict points of ecological network and bigger roads in Estonia. Case study area location is marked.**