The strategic environmental assessment of the Rail Baltic 1435 mm railway county plans of the Harju, Rapla and Pärnu counties

Survey of Biota

OÜ Rewild / Report 2013-4.3 [B]

[B] According to conservation legislation, names and locations of strictly protected species are censored in the public version of the report.

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INTRODUCTION

The Rail Baltic project is launched to create a connection between the railway systems of the Baltic states and continental Europe. Full integration of Estonia, Latvia and Lithuania in the continental Europe railway system has been decided in European Commission level (European Commission's Decision No 884/2004 on 29 April 2004). Construction of the Rail Baltic should facilitate integration of the region through the railway that starts from Helsinki and would connect Tallinn, Riga, Kaunas, Warsaw and Berlin. Initial task of the Rail Baltic plan in Estonia is to find the shortest route alternative from Latvian border to Tallinn (through Pärnu). The task is related to several contradictions. For example, from social point of view it is advisable to avoid settlements, on the other hand routes outside settlements are more likely to cause conflicts with important nature values.

Purpose of this survey is to provide supporting information for finding the suitable location for the route corridor of the railway line in Estonian part of the project in the Harju, Rapla and Pärnu counties. Based on databases, field inventories and computer modelling, we estimated general impacts of the railway on living nature, and brought out particular sites where strong effect would appear on specific species, or ecological or taxonomic groups.

MATERIAL and METHODS

Concept

Geographical region, considered directly in the survey, consists of an approximately 200 km long belt around the railway alternatives from Tallinn via Rapla and Pärnu to Ikla. The survey was carried out from June till October 2013 – a pre-defined timing that included approx. 1.5 months for field inventories, 1 month for data analysis and 1.5 months for synthesis of information gathered. Compared to the extent of the object we admit, it is a relatively short period of time, and bring to notice that the fact should be considered as the main limitation of the task and comprehensiveness of the conclusions. Furthermore, the mid summer is not proper season for inventories of several species groups. Thus, because extensive surveys were not possible, a major part of the procedure was based on computer modeling of wildlife habitats along with consultations of advisory experts and synthesis of various databases (figure 1).

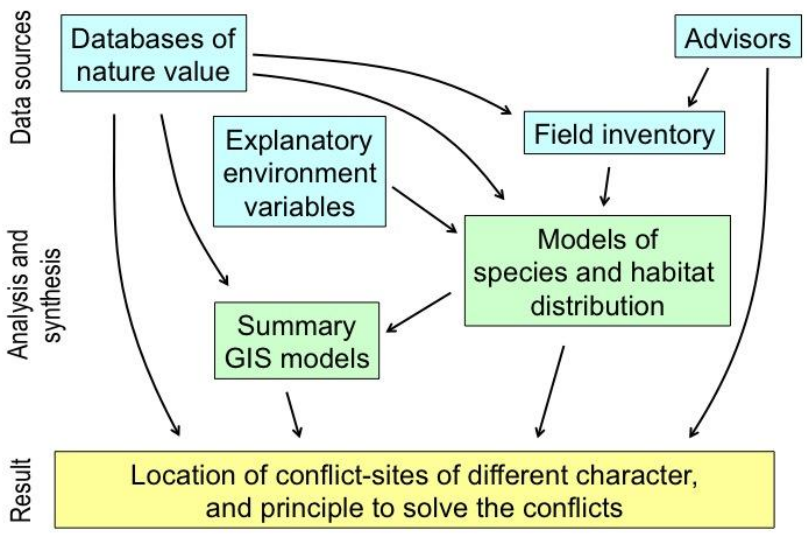


Figure 1. Conceptual scheme of the work procedure – main stages and information flow in the survey from data sources to results and conclusion.

The survey followed an initial route selection, which main criterions for positioning of railway alternatives were related to:

- the Natura 2000 protected areas, other protected areas, and habitats of I and II category protected species;
- settlements;
- heritage objects and areas.

The pre-selection procedure resulted parallel alternative lines (predominantly 2–4, in total length of approximately 700 km) from Tallinn to Ikla, which were under attention of this survey. From ecological point of view, the location of sites for compensating measures and recommendation for the final selection of the railway corridor were based on:

- habitats with high natural value in respect of different groups of animals and plants;
- indicative landscape and habitat variables that are known to relate with high biodiversity or a taxon of high conservation value;

- isolating effect of the railway on animal populations on sides of it;
- intersecting effect on movement corridors, larger dispersal areas and core habitats of animals;
- protected areas and objects near the selected alternative.

Data sources

The analysis was based of three principal types of information: databases (incl. environment registers, topographic data *etc.*), interviews with academic advisors, opinions of flora and fauna experts, and original field inventories (figure 1). The first stage of the study was gathering existing data, defining main conflict regions, and reducing the number of alternative railway lines. The databases we considered in the piloting stages, selection of study areas and following data analysis were:

- EELIS (Environment Register and other sources of Estonian Environmental Board and Estonian Environment Agency) – data of species, areas, and other objects under protection by law;
- Estonian green network (comprechensive plans of counties and municipalities) – used as an important source for detection of dispersal and migration paths of animals, and assessment of population fragmentation by the railway;
- Forest register (http://mets.keskkonnainfo.ee, http://register.metsad.ee) – data of the characteristics of forest habitats, incl. stand composition and age. The source is valuable as most of the Estonian forests are presented in the data table;
- State monitoring program (primely square census of game animals; Department of Game Monitoring, Estonian Environment Agency; but also other monitoring projects) – an important information about animal density distribution, which allows to assess the numbers of large and medium-sized mammals and to locate movement corridors and dispersal areas crossing the railway alternatives. The source is valuable as the data is available throughout the whole planned route;
- Nature Observation Database and eBiodiversity (eElurikkus, http://elurikkus.ut.ee) – background information of distribution of protected and unprotected species (mostly birds and plants);
- databases of various inventories made by different organisations (*e.g.* Estonian Fund for Nature, Estonian Seminatural Community Conservation Association) – this data included valued habitats like mires, meadows, semi-natural habitats *etc*.;
- Protection plans of areas and species (Kivikupitsa landscape protection area, Laiksaare nature reserve, Lemmjõe natural area, Rannametsa-Soometsa nature reserve, Metsaääre nature reserve, planned Nabala landscape protection area, Niidu landscape protection area, Pärnu landscape protection area, Rabivere landscape protection area, Tõrasoo nature reserve) – these provided supporting information about the existing plans and perspectives of protection of species and areas;
- study reports and personal information of distribution of various animal species. Including: inventory results of protected amphibians – northern crested newt (*Triturus cristatus*) and pool frog (*Rana lessonae*) provided by R. Rannap; bird inventories of forest birds and raptors provided by A. Jair and R. Nellis; spatially explicit GIS-based habitat models of northern goshawk (*Accipiter gentilis*), golden eagle (*Aquila chrysaetos*), Eurasian eagle owl (*Bubo bubo*), western capercaille (*Tetrao urogallus*; Leivits 2013), white-backed woodpecker (*Dendrocopus leucotos*; Leivits & Kinks 2012) and three-toed woodpecker (*Picoides tridactylus*; Leivits 2011) composed by M. Leivits (mostly personal, unpublished data); spatially explicit GIS-based bat habitat models of northern bat (*Eptesicus nilssonii*), Brandt's bat (*Myotis brandtii*), pond bat (*Myotis dasycneme*), Daubenton's bat (*Myotis daubentonii*), Natterer's bat (*Myotis nattereri*), common noctule (*Nyctalus noctula*), Nathusius's pipistrelle (*Pipistrellus nathusii*), brown long-eared bat (*Plecotus auritus*) and particoloured bat (*Vespertilio murinus*) composed by M. Leivits (personal, unpublished data); and a dragonfly *Leucorrhinia pectoralis* provided by R. Rannap;
- study reports of specific protected areas or natural communities ordered by The Estonian Environmental Board or other institutions. Including birds of swamps and bogs (Leivits 2002), forest lichens, plants and mosses (Lepik & Reintal 2009), wetland birds of Pärnu county (Tammekänd & Tammekänd 2007a), Rääma bog (Kiristaja 2011), birds of Taarikõnnu and Kaismaa bogs (Tammekänd & Tammekänd 2007b) – backgoung information of particular areas;
- data of GPS-tagged black storks (*Ciconia nigra*, personal communication with R. Rosenvald) – the data enabled to locate important feeding grounds of the I category protected species around the railway alternatives;
- data of road kills in Estona (collected by Estonian Road Administration and Estonian Environmental Inspectorate) – supporting information about animal movement paths and dispersal intensity;
- Estonian National Topographic Database (ETAK) and Map Server of Estonian Land Board (http://geoportaal.maaamet.ee) – general basis for modeling natural habitats of species;
- Estonian Soil Map (Estonian Land Board, http://xgis.maaamet.ee) – important data about distribution of natural habitats, biodiversity and moisture regime;
- aerial and satellite photos (Estonian Land Board, http://xgis.maaamet.ee) – together with other sources of data (*e.g.* forest register) provides a detailed overview about distribution and configuration of natural habitats.

Interviews with advisors

As time for carrying out the surveys (only a part of the vegetation period was usable) was very limited, academic and expert advisors were consulted on the subject of fieldwork methodology and background data, as well as opinions and recommendations for detailing the survey plan. Based on the expert opinions and sugesstions, we considered general impacts on biodiversity, habitats, species dispersal possibilities and other aspects. The persons we consulted with were:
Lauri Klein – dispersal and movement corridors of animals,
Lauri Lutsar – bats,
Andres Kuresoo – birds,
Nikolai Laanetu – aquatic, semiaquatic and game animals,
Asko Lõhmus – forest ecology,
Peep Männil – mammal populations,
Riinu Rannap – ampibians and reptiles,
Kalle Remm – spatial data processing,
Toomas Tammaru – insects,
Indrek Tammekänd – birds of prey,
Uudo Timm – conservation strategy and natural ecosystems,
Urmas Vahur – nature values in Pärnu county,
a professor of botany who wished to be anonymous – plants and communities.

Field inventories

The inventory was preformed in 57 particular study areas. Selection of the areas was based on distribution of habitats of protected species and areas (including Natura 2000), recommendations by advisors, and general experience of ecological processes and biodiversity distribution. The selection of study areas was dynamic, which means that we were capable to select approximately 2/3 of the areas before the fieldworks based on the data sources listed above, and 1/3 of the areas were positioned after the initial analysis and data synthesis. The field inventory was carried out mostly in July 2013. Depending on preliminary results of data analysis and demand for additional data the inventories continued with lower effort until October 2013. During the fieldworks, using a simple, but generally acknowledged techiques of species detection and census (Sutherland 2006), we assessed general value of wildlife habitats, but turned attention on four particular groups of species:

- plants – the inventory was focused on observations and habitats of protected species (lead and performed by Ü. Jõgar). During the inventory protected plants and those habitats were mapped and habitat quality was assessed;
- amphibians – the inventory was focused on breeding waterbodies (performed by K. Suislepp)). During the inventory potential hiqh quality breeding areas of protected amphibians were mapped, and habitat quality was assessed;
- mammals – the inventory was focused on distribution of large and medium-sized animals in different habitats (performed by K. Jaik, J. Remm). During the inventory mammal tracks and other signs of their activity was mapped on line transects, and habitat functionality was assessed;
- raptors – the inventory was focused on search of eagle nests in Rapla and South-Harju county (lead and performed by R. Nellis). During the inventory nests of eagles was searched and mapped by turning attention to known breeding territories with unknown nests location.

Data Analysis

Based on the source databases and inventory results, we compiled 227 GIS levels of environment variables, registered objects and species distributions, including:

- 46 levels of areas of diferent protection regimes,
- 150 levels of species distribution based on the collected data sources and original data of the field inventory and expert opinion,
- 31 levels of explanatory environment variables.

Among the species GIS-levels, we composed 11 high-resolution modelled GIS-levels of mammal habitat quality distribution with MaxEnt algorithm (Phillips and Dudik 2008, Franklin 2009) based on the species observations and tracks mapped during the field

inventories, explanatory environment variables and supporting data sources (mainly state monitoring of game animals). The modelled species in addition to those listed in the section of Data sourches (see above) were moose (*Alces alces*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), red fox (*Vulpes vulpes*), raccoon dog (*Nyctereutes procyonoides*), pine marten (*Martes martes*), badger (*Meles meles*), Eurasian beaver (*Castor fiber*), mole (*Talpa europaea*) and red squirrel (*Sciurus vulgaris*). The modelled area extended up to 5 km from the alternative railway lines, and spatial resolution of the grid pixels was 100 m. As the modelled species represents generally the Estonian terio-fauna, the models in conjunction provided capability to asses relatively precisely spatial pattern of animals' dispersal and movements.

To assess the complex impact of the railway, we composed five spatially explicit summary models with statistic programming language R (R Core Team 2013), revealing distribution of different aspects of nature value:

1) model of area protection strength, based on present and planned protected areas in Environment Register and weighting of those. The weights of different protection regimes was divided respectively:
   • Natura 2000 area or habitat, nature reserve, strict nature reserve, permanent habitat of a species – 1,
   • wldernass conservation zone, woodland key habitat – 0,8
   • salmon river, object of natural heritage – 0,75
   • managed conservation zone – 0,7
   • limited management zone, landscape reserve, limited conservation area, municipality level protected area or object – 0,5
   • green network – 0,25;
2) model of protected species, based on habitats registered in Environment Register and field observations during the inventory. The species weights was divided respectively: I protection category – 1, II cat. – 0.5, III cat. – 0.1;
3) model of habitat quality and movement distribution of large mammals, based on data of field inventory and State monitoring of game animals;
4) model of habitat quality and movement distribution of medium-sized mammals is based on data of field inventory and State monitoring of game animals;
5) model of habitat quality and movement distribution of bats, based on bat habitats registered in Environment Register and opinion of bat experts (M. Leivits and L. Lutsar).

Additionally, we used the high precision model of habitat quality of protected birds: northern goshawk, golden eagle, Eurasian eagle owl, western capercaille, white-backed woodpecker and three-toed woodpecker composed by M. Leivits.

Finally we synthesised the information of the data sources, advisor cunsultations and composed models. During this stage we turned special attention on habitats of protected and unprotected species, natural objects that are protected by law, parts of green network, riparian zones, wetlands, grasslands with high species richness, old forests, and other areas and phenomena that factually have high natural value.

RESULTS and IMPLICATIONS

General impact

The planned Rail Baltic railway would impact natural populations and communities in three principal ways that all potentially decrease environmental capacity and increase probability of local extinctions – via direct loss of natural habitats (decrease of wildlife space), via edge effects and disturbance of neighbouring areas, and via large-scale fragmentation and increased isolation of populations on the sides of the railway (Forman & Alexander 1998).

- Effect of habitat loss can typically overweight the effect of habitat fragmentation on population viability (Fahring 1997). However, the railway will be distinctively a narrow and linear object. The pre-selection procedure of the railway alternative placement resulted very a few intersections throug generally highly biodiverse habitat types (*e.g.* pre-known habitats of protected species, protected areas, old-growth forest stands). Therefore, the effect of habitat loss is expectedly minimal, compared to the effects of population fragmentation, as well as edge and indirect effects of neighbourhood (Ewers & Didham 2006).
- Effects of the sharp habitat edge of the railway corridor is potential to appear via audial (and visual) disturbance, or altered soil water regime and local microclimate in the vicinity of the railway. The water regime alteration impacts directly plants, and the

altered plant community has potentially a consequence on a large number of other species. Therefore, preserving a local water regime is crucial for minimizing general effects of the railway on local biota.

The species that are expectedly most strongly affected by the railway noise and other human activity, are birds. Audio-visual disturbance and other edge effects on forest and wetland birds can extend up to 1 km (eagles, black stork, capercaillie lek), but for most of species is less than 0.2–0.3 km (Kontkanen *et* al. 2004, Ruddock & Whitfield 2007, Thiel *et al*. 2011). Therefore, noise barriers or other compensating measures could be relevant near habitats of disturbance sensitive species (*e.g.* capercaillie lek grounds).

- Habitat fragmentation could potentially isolate populations on the sides of the railway, and through this reduces viability of the populations. The lower viability of the populations causes higher number of local extinctions, and consequently brings biodiversity loss. The effect could be most critical on terrestrial non-fledged animals, which are not capable to cross the fenced railway by their native way of locomotion. Most likely affected species are large mammals (ungulates and large carnivores), which have large space requirement and are not capable to cross a fully fenced railway if special passages are not constructed (Iuell *et al*. 2003, Klein 2010).

  Medium-sized mammals (approx. body size from marten to badger) do not pose a considerable threat to the railway traffic. Therefore, constructing the fences in a way that is fully passable for these species can minimize the effect of habitat fragmentation on them.

  Small terrestrial animals like rodents, shrews, amphibians and reptiles are often not capable to cross over even the rails. It is noteworthy that a large number of these species are under protection of law (all amphibians and reptiles, and some rodents), and are potentially affected by the habitat intersecting effect of the railway. Thus the railway could be a strong population isolator even if the fences are highly passable for the species. Therefore, special pass-throughs under the rails are required all along the way.

Overview of the inventory

In total, 57 study areas that all together covered most of the range of the railway alternatives were inventoried in respect of at least one aspect (see layout and descriptions on the subsequent map 1 and list 1). Some of the areas were specific places and other were larger regions that needed general inspection.

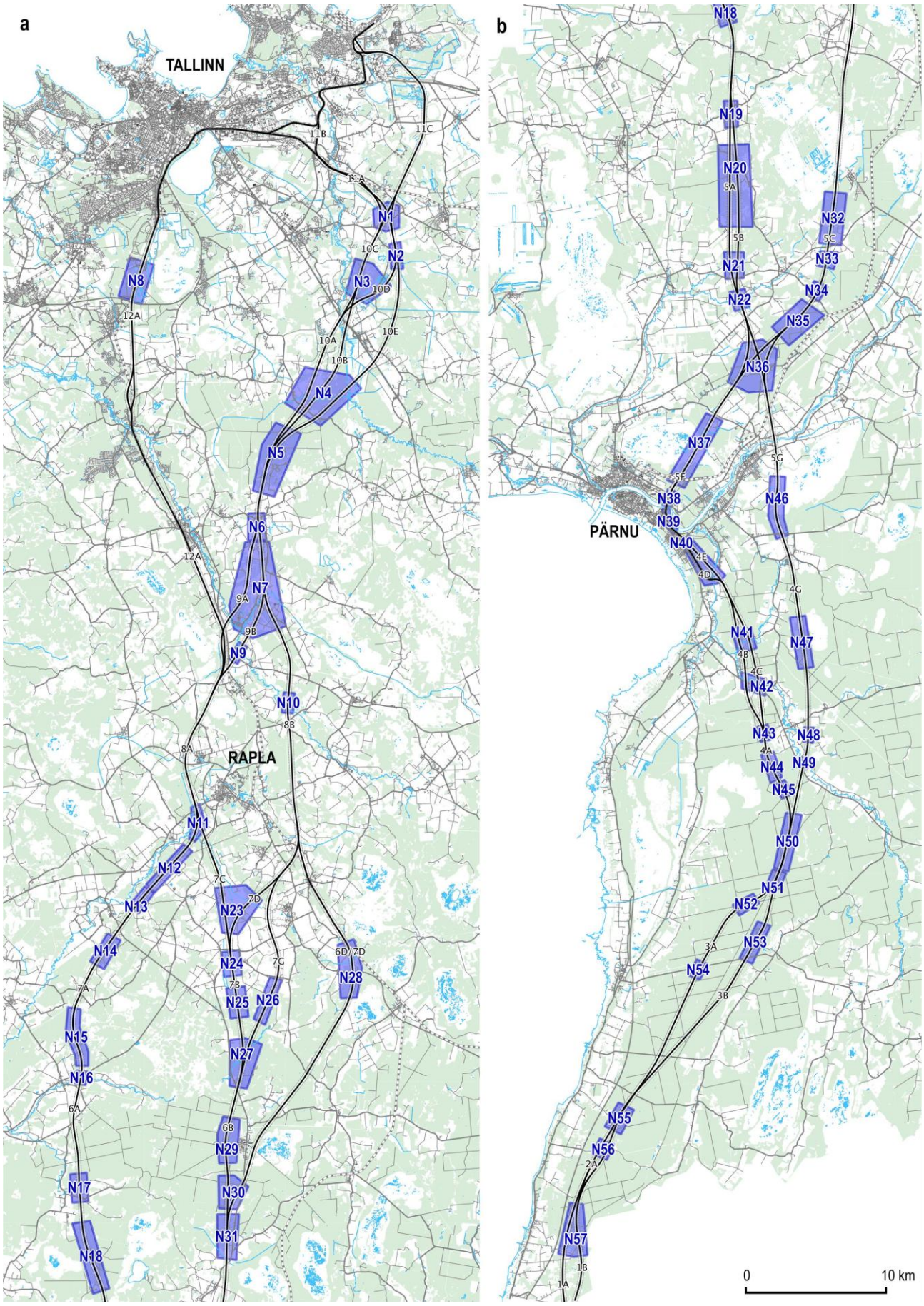
The plant inventory was performed in 24 study areas: N2, N3, N4, N5, N10, N11, N12, N13, N31, N37, N38, N42, N43, N44, N45, N46, N49, N51, N52, N53, N54, N55, N56, N57. Among these, we observed species or habitats in 11 areas that clearly conflict the railway and deserve attention.

The amphibian inventory was performed in 28 study areas: N1, N4, N6, N9, N11, N14, N16, N17, N18, N19, N20, N21, N22, N24, N25, N31, N33, N34, N36, N37, N40, N41, N42, N46, N48, N49, N56, N57. Among these, we found high quality habitats in 12 areas that could be significantly affected by the railway.

The mammal inventory was performed in 33 study areas: N2, N3, N4, N5, N7, N8, N11, N12, N18, N20, N27, N29, N30, N31, N32, N35, N36, N37, N39, N40, N43, N44, N45, N46, N47, N50, N51, N52, N53, N54, N55, N56, N57. Among these 24 study areas are situated in core habitat or dispersal areas, where compensating measures are clearly relevant.

The inventory of raptor nests was performed in 8 study areas: N4, N6, N7, N12, N13, N23, N26, N28. Among these, we found raptor nests on an alternative railway line in 2 areas.

Map 1. Placement of the field inventory study areas along the railway alternatives in northern (a) and southern (b) half of the survey region – see overview of the inventory results in the subsequent list 1.



List 1. Overview of the study areas and inventory results. The areas listed here are depicted in the map 1; see maps 7–12, and tables 1–6 for layout of corresponding conflict sites on the railway lines.

Explanation of the structure of the list

Code of study area | *railway sections | species groups under attention | coding of related conflicting site*
Overview and descriptions

N1 | 11A, 11C | amphibian inventory | 11

The railway alternatives cross high-quality habitats (ponds and meadows) of amphibians (III cat.) *Rana temporaria, R. arvalis, Bufo bufo* and *Triturus vulgaris*. Railway has potentially a strong impact on the populations via loss and change of water bodies and soil water regime.

N2 | 10D/10E | plant and mammal inventory, bat expert opinion | 13

The study area is situated on the border of drained meadow (west) and mid-aged deciduous forest (east) separated by a large ditch. The nearby Natura 2000 habitat types (9080, 9020, 91D0, 7110) on the east side of the railway line can be affected if soil water regime changes. No protected plants observed near the railway line during the inventory.

The large ditch and surrounding trees is a feeding habitat and moving corridor of bats (II cat.). The forest, eastward from the railway line, is core-habitat of large mammals, mostly ungulates. In the southern part of the area is probable moving area of the large and medium-sized mammals crossing the railway line.

Shifting the railway line westward onto the meadow can reduce the effect of area loss of natural habitats.

N3 | 10C, 10D | plant and mammal inventory, bat expert opinion | 14, 15, 16

Highly valuable habitat complex – grassy spruce stands mixed with broad-leaved (oak, ash) stands, swamp forests, and calcareous meadows (Natura 2000 habitat types 2050, 9020, 9080 and 7230). The high value habitats are situated mostly on the east side of the railway alternative 10C, and those are worth special attention and protection. Railway has potentially strong impact via loss of area and change of water regime. The impact can be partly reduced by shifting the railway line westward.

Observations of III cat. protected plants *Platanthera* sp., *Dactylorhiza fuchsii* and *Neottia nidus-avis* around the railway alternative 10C.

The area is an important core-habitat for mammals of every size, *e.g.* moose, wild boar, badger, pine marten, red squirrel, voles *etc*. Placement of passthrough for large mammals is recommended on northern part of the study area. The large ditch and surrounding woodlands southward from the study area, is a feeding habitat and moving corridor of bats (II cat.).

N4 | 10A, 10B, 10E | plant, mammal, raptor and amphibian inventory, bat expert opinion | 22, 23, 24, 25, 26, 27, 28, 29, 30

The study area is a complex of high-quality natural bog, other wetland and mesic forest habitats, natural and agricultural grasslands and riverside alluvial habitats. The impact of the railway is stronger on the western part of the study area. Crossing of the natural wetland (Saarte raba) has large-scale effect for natural habitats, which is probably impossible to compensate.

No protected plants observed near the railway lines during the inventory, but the general rating for habitat quality is high on west part of the area (esp. the bog).

The railway alternative 10A crosses the nest of I cat. protected bird, and passes another nest at a close distance. The bog, passed through by railway alternatives 10A and 10B, is a lek ground of III cat. protected black grouse (*Tetrao tetrix*), and is a feeding area of bats (II cat.). Whole study area covers important core-habitats and dispersal area of large mammals, *e.g.* moose, wild boar, roe deer. Thus, passthroughs for large and medium-sized mammals are required. The railway alternative 10E crosses habitats of amphibians (III cat.), *Rana temporaria, R. arvalis* and *Triturus vulgaris*, and semiaquatic mammals (*e.g. Castor fiber* and *Lutra lutra*; III cat.) on eastern part of the area related to the Pirita river, nearby channels and surrounding alluvial habitats.

N5 | 9A/9B, 10A, 10B, 10E | plant and mammal inventory | 31, 32, 33, 34, 35, 36

The study area is situated in a large forest area that is intensely managed (many clear cuts), and has strong human impact for natural habitats. Previously, habitats of several protected plants are known. The study area covers important forest habitats of protected birds (I–III cat.).

Observations of II and III cat. protected plants around all railway alternatives made during the inventory.

The study area is an important core-habitat and dispersal area of mammals of all sizes, *e.g.* brown bear, lynx, moose, wild boar, roe deer, pine marten, red squirrel, voles *etc*. Placements of passthroughs for large mammals are recommended in northern part of the study area.

N6 | 9A, 9B | amphibian and raptor inventory, bats expert opinion | 48, 49

In this study area, the railway alternatives cross high-quality habitats of amphibians (III cat.) *Rana temporaria, R. arvalis, R.*

lessonae and *Bufo bufo*. Impact of railway is potentially strong, but can be reduced by shifting the railway line eastward. On the northern part of the area, the railway line crosses feeding habitat of bats (II cat.) related to the Angerja brook and nearby wooded meadows.

No raptor nests observed during the inventory.

N7 | 9A, 9B, 8B | mammal and raptor inventory | 50, 51, 52

In this study area the railway alternatives 9A and 9B cross high-quality habitat landscape and important movement corridor of large and medium-sized mammals, *e.g.* moose, wild boar, roe deer, lynx, fox, hares, pine marten *etc*. Demand for animals passtrough is in the northern part of the area.

No raptor nests observed during the inventory.

N8 | 12A | mammal inventory, bat expert opinion | 41, 42

The study area is situated in suburban green area. An important feeding habitat of bats (II cat.) is related to the ponds near the railway line in the current and previous areas of Männiku sand quarry. The surrounding forests and Männiku bog are suburban habitat of ungulates, mostly moose and roe deer. Thus a passthrough for the large mammals is recommended in northern part of the study area.

N9 | 9B | amphibian inventory, bat expert opinion | 57

In this study area, the railway alternative 9B crosses habitats of amphibians (III cat.) *Rana temporaria, R. arvalis, Bufo bufo* and *Triturus vulgaris* and bats (II cat.) related to the alluvial plain and riparian woodlands of the Keila river. Expectedly, no significant effects appear on populations if the bank path for animals and alluvial plain water regime is retained.

N10 | 8B | plant inventory, bat expert opinion | 61, 62

In this study area, the railway alternative 8B passes through a wetland forest habitat near Maidla swamp. No protected plants observed during the inventory, but it is important to turn attention to preservation of water regime in order to avoid large-scale effects on wetland habitats in the surrounding areas.

A bat feeding habitat and moving corridor follows the Keila river in the southern part of the study area.

N11 | 7A, 7C, 8A | plant, mammal and amphibian inventory, bat expert opinion | 64, 65, 66

In the northen part of the study area, the railway alternatives 7C (and partly also 7A) cross a meadow of low conservation value (recent agricultural origin), but with relatively large population of orchid *Gymnadenia conopsea* (III. cat. plant).

In the northern and southern parts of the study area, railway lines cross habitats of amphibians (III cat.) *Rana temporaria, R. arvalis* and *Bufo bufo,* related to the alluvial plains of Vigala and Kuusiku rivers. The railway alternative 7A passes a larger bat feeding area related to Kuusiku river and surrounding forests. In the same part of the area is a moving corridor of ungulates. Moving corridor of semiaquatic animals follows the Vigala river. Impact of the railway can appear via area loss of forest and alluvial habitats, and via reduced connectivity of mammal populations. No significant effects of the railway expected on riparian populations if water regime of Vigala and Kuusiku rivers and those alluvial plain is retained.

N12 | 7A | plant, mammal and raptor inventory | 68, 69

Observations of II cat. protected plant on calcareous meadow in the middle of the study area. The semi-natural calcareous meadow next to the Susla road, in the middle of the area has a high habitat value, and needs special attention. Significant impact can appear via area loss.

The forest habitat, westward from the railway line is a high-quality habitat for large and medium-sized mammals, *e.g.* moose, roe deer, wild boar, badger *etc.* There is known a territory of I cat. protected bird of prey, but no raptor nests observed during the inventory in the vicinity of the railway line.

To reduce the effect of the railway, it is recommended to shift the line eastward onto the border area of the open agricultural field, and preserve the natural and semi-natural habitats.

N13 | 7A | plant and raptor inventory

No protected plants and raptor nests observed during the inventory. Expectedly, the effect of the railway on natural populations is not significant.

N14 | 7A | amphibian inventory

Habitats of amphibians (III cat.) *Rana temporaria* and *R. arvalis*, relatively far from the railway line. Expectedly, the railway does not have significant effects on the amphibian populations.

N15 | 7A | plant, mammal and bird inventory | 73, 74, 76

The study area is situated in large forest and wetland area that is rich in natural matter. The area consists of different mesic and wetland forests, and swamp habitats. II and III cat. protected plants were observed during the inventory on calcareous meadows under the power-lines approx. 1 km northward from the study area. Provided that water regime persists, the impact of the railway appears mainly via area loss. In the northern part of the area, it is recommended to shift the railway line

westward and preserve water regime, as there are several known protected plants in the eastward Tõrasoo wetland (Natura 2000 habitat type 7230).

Entire study area and surrounding areas contain an important large-scale dispersal area of mammals – ungulates, large carnivores as well as medium-sized mammals. The railway can reduce large-scale population connectivity of mammals. Thus, an animal passthrough is important. The best site for animal passthrough appears to be in the northern part of the study area.

The southern part of the study area is known as a habitat for several II and III cat. protected birds. Thus, it is recommended to reduce width of the railway corridor in order to save forest habitats for wildlife.

N16 | 6A | amphibian inventory | 77

Railway crosses alluvial habitats of amphibians (III cat.) *R. arvalis* and *Bufo bufo* on the plain meadows of Velise river. Weak effects could be expected on the populations if railway affects water regime.

N17 | 6A | amphibian inventory, bat expert opinion | 81

Railway crosses alluvial habitats of amphibians (III cat.) *Rana arvalis* and *Bufo bufo*, and feeding habitat of bats (II cat.) near the Nurtu river and surrounding wooded meadows.

N18 | 6A | mammal and amphibian inventory, bat expert opinion | 82, 83

The study area is situated in large forested area between natural wetlands (Rogenese and Kaisma bogs). Entire study area, but especially the northern part of it, contains an important large-scale dispersal area of mammals – ungulates, large carnivores as well as medium-sized mammals. The railway can impact the mammal populations via reduced large-scale population connectivity. Thus, an animal passthrough is important. Recommended place for the animal passthrough is situated in the northern part of the study area.

In the southern part of the study area, below average quality habitat (forest ditches) of amphibian (III cat.) *Rana temporariai* is situated. No significant effects of the railway expected.

In the southern part of the study area, the railway line crosses forest swamp meadows that are valuable feeding habitats of bats. It is recommended to shift the railway eastward.

N19 | 5A, 5B | amphibian inventory

The study area contains a below average quality habitat of amphibian (III cat.) *Rana arvalis*. Expectedly the railway does not have significant impact on the amphibian populations.

N20 | 5A, 5B | mammal and amphibian inventory, bat expert opinion | 90, 94, 96

The study area is situated in large forested area that is a large-scale dispersal area of mammals – ungulates, large carnivores as well as medium-sized mammals. The railway can impact the mammal populations via reduced population connectivity. Thus, an animal passthrough is recommended. The recommended site for animal passtrough is in the southern part of the area.

Near northern border of the study area is a bat (II cat.) feeding habitat related to forest swamps on the railway alternative 5B.

In the middle of the study area, below average quality habitat of amphibian (III cat.) *Rana arvalis* is situated. Expectedly the railway has no significant effects on the amphibian populations.

N21 | 5A, 5B | amphibian inventory, bat expert opinion | 97, 98

The study area is situated on alluvial plain of the Are river. The wooded meadows along the river are high-quality feeding habitat for bats (II cat.). The alluvial habitat is below average quality for amphibian (III cat.) *Rana arvalis*. Expectedly, the railway has no significant effects on the amphibian population.

N22 | 5A/5B | amphibian inventory, bat expert opinion | 101

The study area is situated on the alluvial plain of the Sauga river. The surroundings of the river and nearby trees are valuable feeding habitat for bats (II cat.). Alluvial wetland habitats are valuable for amphibians (III cat.) *Rana arvalis* and *Bufo bufo* near the river. Provided that water regime and riparian animal path persists, the railway is expected to have no significant impact on the populations.

N23 | 7C, 7D | raptor inventory | 102

Nest of protected bird (I cat.) is situated on the railway alternative 7D. The impact of the railway is significant, and it is probably not possible to compensate.

N24 | 7B | amphibian inventory | 103

In this study area, the railway line crosses high-quality breeding habitats (ponds and surrounding woodland) of amphibians (III cat.) *Rana temporaria, R. arvalis, R. lessonae, Bufo bufo* and *Triturus vulgaris*. Impact of the railway is potentially strong. The adverse effect can be reduced by shifting the railway line eastward.

N 25 | 7B | amphibian inventory

The study area contains below average quality habitat of amphibian (III cat.) *Rana arvalis*. Expectedly, the railway does not have significant effects on the populations.

N26 | 7G | raptor inventory

No raptor nests observed during the inventory. Expectedly the railway does not have significant effect on the nearby raptor territories.

N27 | 6B, 7B, 7G | mammal inventory, bat expert opinion | 105, 106, 107

In this study area the railway alternative 7G passes nearby habitat of a II cat. protected bird and Natura 2000 habitat type 9010. Those can be affected if the railway cuts through or runs very close to the habitats. Thus, it is recommended to shift the railway line westward, apply measures that reduce railway noise, and avoid construction activity during breeding season (March-June). Additionall study or expertise of the bird space use and population connectivity may be required.

Entire study area, and surrounding forests and wetlands contain an important core-habitat and large-scale dispersal area of mammals – ungulates, large carnivores as well as medium-sized mammals. The railway can impact mammals via reduced large-scale population connectivity. Thus, an animal passthrough is necessary. The best site for animal passthrough appears approx. 1 km northward from the study area.

Thr railway lines cross bat feeding habitat along the Velise river.

N28 | 6D/7D | raptor inventory

No raptor nests observed during the inventory. Expectedly the railway does not have significant effect on the nearby raptor territories.

N29 | 6B | mammal inventory | 117

The railway line is situated close to a habitat of II cat. protected bird in the middle of the area. The impact of the railway is supposedly weak.

The study area is situated in a large forested area that is an important core-habitat and large-scale dispersal area of mammals – ungulates, large carnivores as well as medium-sized mammals. The railway can impact mammals via reduced large-scale population connectivity. Thus, an animal passthrough is necessary. The recommended place for animal passthrough is on the southern border of the study area.

N30 | 6B, 6D/7D | mammal inventory | 119

The study area is situated within large core-habitat and dispersal area of medium-sized and large mammals, but the habitat value is slightly lower than surrounding areas, esp. in the north.

The railway alternative 6B passes close to a habitat of a II cat. protected bird. The impact of railway can be significant if the railway passes very close to that. Thus, it is recommended to shift the railway line eastward, apply measures that reduce railway noise, and minimize railway construction activity during breeding season (March-June). Additionall study or expertise of capercaille space use and population connectivity may be required.

N31 | 5C | plant, mammal and amphibian inventory, bat expert opinion | 120

In this study area the railway line is situated close to habitats of several protected plants (II and III cat.) in the wetland westward from the line. The impact of the railway is supposedly weak. No protected plants observed during the inventory.

The study area is situated within large core-habitat and dispersal area of medium-sized and large mammals, but the habitat value is slightly lower than surrounding areas in the north.

In southern part of the study area, the railway line passes through below average quality habitat of amphibian (III cat.) *Rana arvalis*. Effect of the railway on the population is expectedly weak.

In the northern part of the area is situated a bat (II cat.) feeding habitat related to forest swamps on the railway line.

N32 | 5C | mammal inventory | 123, 124

The study area is situated close to the southern border of Tootsi peat milling fields that concentrate animals movement in surrounding forests. In the northern part of the study area is a moving corridor of medium-sized and large mammals, incl. moose, wild boar, roe deer, wolf, lynx, bear and several smaller animals. The railway can impact mammals via reduced large-scale population connectivity.

In the surroundings of the study areas, a territory of a protected bird (I cat.) is known. Exact nest site has not been positioned yet. If the nest is located close to the railway line, the impact is probably significant on the territory. Abandonment of the nest-site can be possible. Additional survey of raptor nests is recommended.

N33 | 5C | amphibian inventory | 125

In this study area, the railway line passes below average quality habitat of amphibians (III cat.) *Rana arvalis* and *Bufo bufo* related to alluvial plain of the Sauga river. Provided that the bank path of semiaquatic animals persists, no significant effects of the railway are expected.

N34 | 5C | amphibian inventory

In this study area, the railway line passes below average quality habitat of amphibians (III cat.) *Rana arvalis* and *Bufo bufo*. No significant effects of the railway expected, but retaining large-scale water regime is required.

N35 | 5C | mammal inventory | 128

The study area is situated on the border of large-scale dispersal area of medium-sized and large mammals, but the habitat value is slightly lower than that of the bordering areas in the south.

N36 | 5A/5C, 5F/5G | mammal and amphibian inventory | 127, 128

The study area is situated in a core-habitat and moving corridor of large and medium-sized mammals – moose, wild boar, roe deer, lynx, badger, hares *etc*. Impact on population connectivity can be significant. Thus, an animal passtrough is required in the northern part of the study area.

Habitats of amphibians (III cat.) *Rana temporaria, R. arvalis* and *Bufo bufo* are situated in the southern part of the study area. As the habitat water-bodies are situated relatively far from the railway line, no significant effect is expected from the railway.

N37 | 5F | plant, mammal and amphibian inventory | 131, 132

The study area is situated in a complex of high-quality natural Rääma bog and surrounding mesic forests. The bog is a habitat of several III cat. protected birds. The impact of the railway crossing of natural wetland is significant. Large-scale effects on natural habitats are probably not possible to compensate.

Small and apparently decreasing population of protected plant *Thalictrum lucidum* (III cat.) was observed during the inventory in the northern part of the area.

The bog and southern forests contain a mammal movement area that is important for local populations. The railway affects ungulates and medium-sized mammals. The railway line passes habitats of amphibians (III cat.) *Rana arvalis, R. temporaria, Bufo bufo* and *Triturus vulgaris,* in the southern part of the area.

N38 | 5F | plant inventory | 133

The study area is situated in a valuable pine-broadleaved mixed old forest. The small area is occupied by many protected plants. *Neottia nidus-avis*, *Epipactis helleborine*, *Huperzia selago* and *Platanthera* sp. (all III cat.). near the present railway were observed during the inventory. Impact of the railway appears via area loss and potentially via microclimatic change if only narrow forest patch/stripe is retained eastward from the railway. Habitat of *a* II cat. and *a* III cat. protected plant under the high-voltage power line have significantly decreased previously.

N39 | 5F | bat expert opinion, mammal inventory | 134, 135

The study area consists of riparian habitats of the Pärnu river. The area is an important feeding and moving habitat for bats and semiaquatic mammals. Provided that the wooded habitats along river banks persist and the bridge is as high as the current road and railway bridge, no significant effects are expected.

N40 | 4D, 4E | mammal and amphibian inventory | 136, 137, 138, 139

The study area contains higly valuable old-growth forest habitat (Natura 2000 habitat type 9010) that is occupied by several protected birds (III cat.) and a lizard (II cat.). Railway passing through these stands has significant impact, but this can be reduced by using the old railway corridor and keeping the new railway corridor not wider than the remaining corridor of the old railway.

The area is a suburban habitat of ungulates and smaller mammals – wild boar, roe deer, pine marten, red squirrel *etc*. The surroundings of the Reiu river in the southern border of the study area, and the old forest are important breeding and feeding habitat of bats (II cat.). Railway crosses alluvial habitats of amphibians (III cat.) *Rana arvalis* and *Bufo bufo*, in the southern part of the study area on the plain of the Reiu river.

Additional study or expertise of the lizard habitat use and population connectivity may be required.

N41 | 4B, 4C | amphibian inventory, bat expert opinion | 140, 141

The railway lines cross alluvial habitats of amphibians (III cat.) *Rana arvalis* and *R. temporaria*, and feeding habitat of bats along the river Vaskjõgi.

N42 | 4B, 4C | plants and amphibian inventory, bat expert opinion | 142, 143

The railway lines cross below average quality alluvial habitats of amphibian (III cat.) *Bufo bufo*, and feeding habitat of bats along the Reiu river.

No protected plants observed during the inventory.

N43 | 4A | plant and mammal inventory | 144, 145

The area is situated in a large forest area. The railway alternative passes close to Natura 2000 habitat types 9010, 6450 and 91F0 that can be affected by area loss and change of water regime. No protected plants observed during the inventory, but the alluvial area of the Ura river has relatively high habitat value in general.

The study area is situated within a larger core-habitat and dispersal area of medium-sized and large mammals. The habitat quality is increasing towards south.

N44 | 4A | plant and mammal inventory | 147

In this study area, the railway alternative passes close to Natura 2000 habitat types 9010 and 91D0, and habitat of II cat. protected bird. These habitats can be affected by area loss and changed water regime. It is recommended to shift the railway line eastward, apply measures that reduce railway noise, and avoid construction activity during breeding season (March-June). Additionall study or expertise of the species space use and population connectivity may be required. No protected plants observed during the inventory.

The study area is situated within a core-habitat and dispersal area of medium-sized and large mammals (incl. ungulates and large carnivores), but habitat quality is higher in surroundings.

N45 | 4A | plant and mammal inventory | 161

In this study area, the railway line runs close to Natura 2000 habitat types 9010 and 91D0, that can be affected by area loss and changed water regime. No protected plants observed during the inventory.

The study area is situated within a core-habitat and dispersal area of medium-sized and large mammals (incl. ungulates and large carnivores). A recommended place for animal passthrough is situated southward from the study area.

N46 | 5G | plant, mammal and amphibian inventory | 150, 151, 152, 153

The study area is situated on the border of high-value Kõrsa bog that is habitat for several protected birds (I–III cat.). The bird populations can be affected by disturbance and noise of the railway. Expectedly, the impact is strongest during bird breeding season (April–June). The nearby Natura 2000 habitat types (91D0*, 910*, 7110*, 7120) can be affected via change of water regime and area loss.

The inventory resulted observations of a protected plant (III cat.) around the railway line in the southern part of the study area; and II and III cat. protected plants on the railway line in the middle part of the study area. The meadows in the middle of the area have high habitat value and are worth special attention and protection. Railway impact could be significant.

In the middle of the study area is situated a moving corridor of large mammals (mostly ungulates) along the bog bordered forests. Railway line passes habitats of amphibians (III cat.) *Rana temporaria, R. arvalis* and *Bufo bufo* in forests and ditches. Expectedly, the impact of the railway is weak on the amphibian populations if water regime persists.

N47 | 4G | mammal inventory | 156, 157

In this study area the railway line passes between two natural wetlands – Valgeraba bog and a swamp forest in the west. Provided that water regime persists, the railway impact on the wetland habitats and nearby Natura 2000 habitat types 9080, 91D0, 9010, 7110 is not significant.

The study area is situated within a core-habitat and dispersal area of medium-sized and large mammals, but supposedly, habitat quality and dispersal intensity is higher approx. 2 km northward and 2 km southward from the study area.

The railway alternative passes habitat of II cat. protected bird. Thus, it is recommended to apply measures that reduce railway noise, and minimize construction activity during breeding season (March-June). Additional study or expertise of the bird space use and population connectivity may be required.

N48 | 4G | amphibian inventory, bat expert opinion | 159

In this study area, the railway line crosses below averege quality alluvial habitats of amphibian *Bufo bufo* and bat feeding habitat along the Surju brook. No significant effects of the railway expected if movement possibility of bats and semiaquatic animals persists.

N49 | 4G | plant and amphibian inventory | 160

In this study area, the railway line crosses feeding habitat and moving corridor of bats on the Reiu river. No protected plants and valuable habitats of amphibians observed during the inventory, but the alluvial area of the Reiu river is worth attention as it is potential habitat for several protected species.

N50 | 3A/3B | mammal inventory | 163

The study area is situated within a core-habitat and dispersal area of medium-sized and large mammals, incl. moose, roe deer, wild boar, lynx, wolf, bear, badger, *etc*. Habitat quality and dispersal intensity is higher northward from the study area.

The railway line passes close to habitat of a II cat. protected bird. It is recommended to apply measures that reduce railway noise, and minimize construction activity during breeding season (March-June). Additionall study or expertise of the bird space use and population connectivity may be required.

N51 | 3A/3B | plant and mammal inventory | 164

In the northern part of the study area, railway line passes close to highly valuable old-growth forest patch (eastward from the line) that is breeding and feeding habitat for bats (II cat.) as well as several II and III cat. protected birds and plants. Very probably the old-growth stand contains several additional conservation values. No protected plants observed during the

inventory. For large and medium-sized mammals the study area has lower habitat value than surrounding areas. The large ditch Timmkanal is potentially valuable habitat and moving corridor for semiaquatic animals (incl. otter and beaver).

N52 | 3A | plant and mammal inventory | 165, 166

The study area consists of young and mid-aged intensely managed forests. Near the study area are Natura 2000 habitat types 9010, 9080 and 9050. During the inventory, *Epipactis helleborine* (III cat. plant) was observed on the railway line. Provided that general water regime persists, no significant effects of the railway expected on the habitats and plant populations.

The study area is situated within an important core-habitat and dispersal area of large mammals, *e.g.* moose, wild boar, roe deer, lynx, wolf, bear, badger, pine marten *etc.* Habitat quality and dispersal intensity is higher southward from the study area, where an animal passthrough is recommended.

N53 | 3B | plant and mammal inventory, bat expert opinion | 171, 172, 173, 174

In this study area, main habitat values are related to old and mixed-aged natural forests. The inventory resulted observations of *Epipactis helleborine* (III cat. plant) near Aruoja boulder and sorroundings in the southern part of the study area. In the middle and in the southern part of the study area the railway line passes through highly valuable mesic and swamp old-growth forests that are habitat for II and III cat. protected bats, birds and plants. Impact of the railway could be significant via area loss even if water regime persists fully.

The study area is situated within an important core-habitat and dispersal area of large mammals, *e.g.* moose, wild boar, roe deer, lynx, wolf, bear, badger, pine marten *etc.* Habitat quality and dispersal intensity is higher northwards from the study area, where an animal passthrough is recommended.

N54 | 3A | plant and mammal inventory | 168

The study area consists of intensely managed forests, with sparse remnants of valuable old coniferous stands. The inventory resulted observations of protected plant *Plathanthera* sp. (III cat.). in the old pine forest around railway line. Impact of the railway appears mainly via area loss of the old-growth stands.

The railway line passes close to habitat of a II cat. protected bird, but the highest habitat quality is placed relatively far from the railway line. Still, it is recommended to apply measures that reduce railway noise, and minimize construction activity during breeding season (March-June). Additional study or expertise of the bird space use and population connectivity may be required.

The study area is situated within an important core-habitat and dispersal area of large mammals, *e.g.* moose, wild boar, roe deer, lynx, wolf, bear, badger, pine marten *etc.* Habitat quality and dispersal intensity is higher in surroundings farther from the Tõitoja – Häädemeeste road.

N55 | 2A/2B | plant and mammal inventory | 179

In the study area, the railway line passes between highly valuable old-growth forests that are occupied by II and III cat. protected birds and plants. Impact of the railway could be significant via loss of old-growth habitats. Supposedly the impact can be effectively reduced if width of railway corridor is reduced. No protected plants observed during the inventory.

The study area is situated within an important core-habitat and dispersal area of large mammals, *e.g.* moose, wild boar, roe deer, lynx, wolf, bear, badger, pine marten *etc.* Habitat quality and dispersal intensity tend to be higher south from the study area.

N56 | 2A, 2B | plant, mammal and amphibian inventory | 182, 183

In the study area, the railway lines cross Natura 2000 stream Lemmjõgi. The stream and nearby areas are moving corridor for semiaquatic mammals, *e.g.* otter (*Lutra lutra*; III cat.). No protected plants observed during the inventory. The railway lines cross habitat of amphibians (III cat.) *Rana temporaria*, *R. arvalis* and *Triturus vulgaris*, mostly related to the ditches on the meadow northward from the stream.

The study area is situated within an important core-habitat and dispersal area of large mammals, *e.g.* moose, wild boar, roe deer, lynx, wolf, bear, badger, pine marten *etc.* Habitat quality and dispersal intensity tend to be higher south from the study area.

N57 | 1A, 1B | plant, mammal and amphibian inventory | 186, 187

The study area is situated in a larger area of valuable grassy forests and several protected plants. The inventory resulted observations of III cat. protected plants – *Huperzia selago*, *Platanthera* sp., *Epipactis helleborine* and *Dactylorhia* sp. Expectedly, the railway impact on the plant populations appears mainly via loss of habitat area. The railway alternative 1A is situated close to high-quality breeding habitat (forest ponds) of amphibians (III cat.) – *Rana temporaria*, *R. arvalis* and *Triturus vulgaris*. Weak effects on the amphibian populations is expected via water regime change.

The study area is situated within an important core-habitat and dispersal area of large mammals, *e.g.* moose, wild boar, roe deer, lynx, wolf, bear, badger, pine marten *etc.* Habitat quality and dispersal intensity tend to be higher north from the study area.

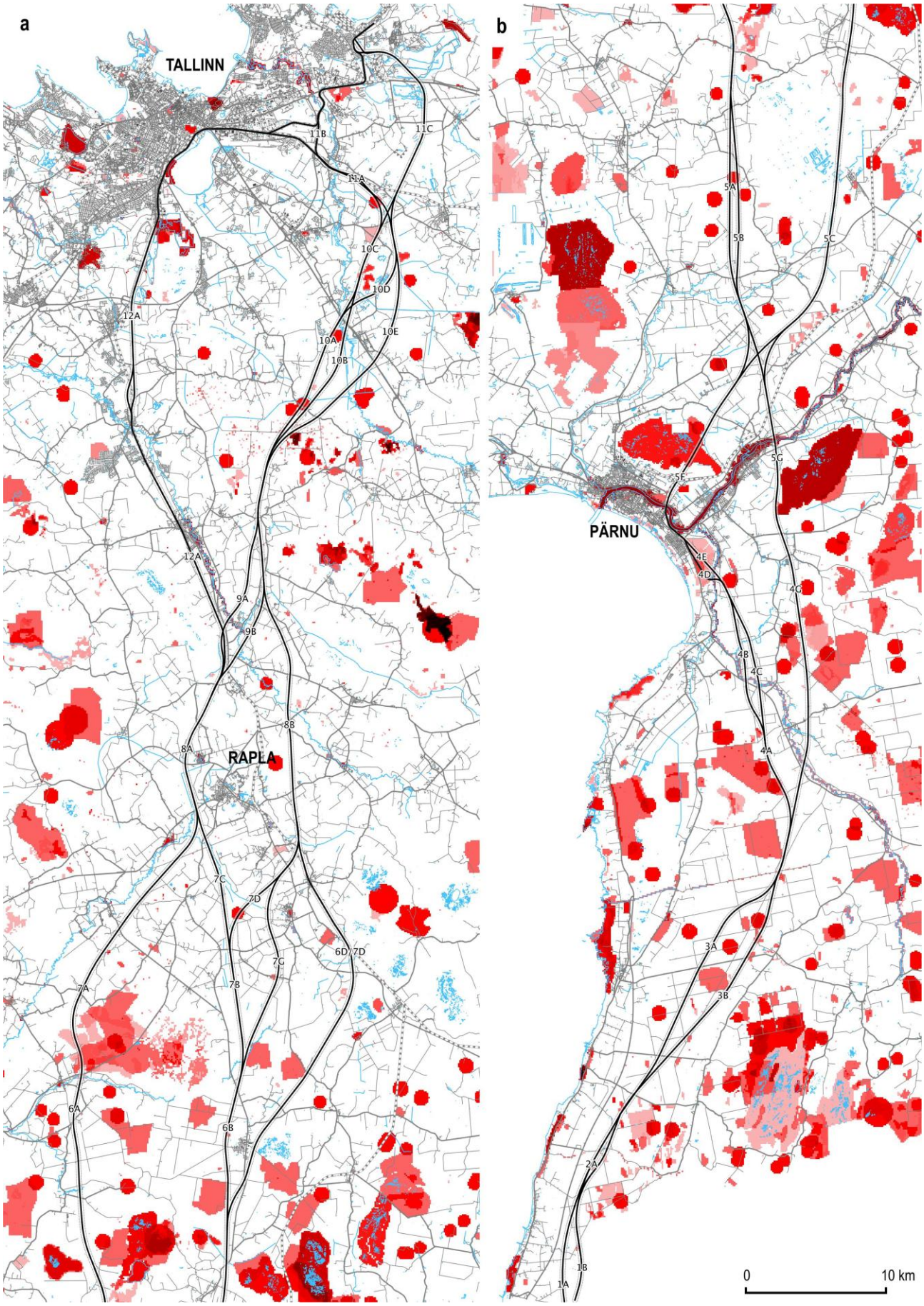
Summary models

Based on the species observations collected during the field inventories and additional data sources, we composed five spatially explicit models revealing distribution of different aspects of nature value:

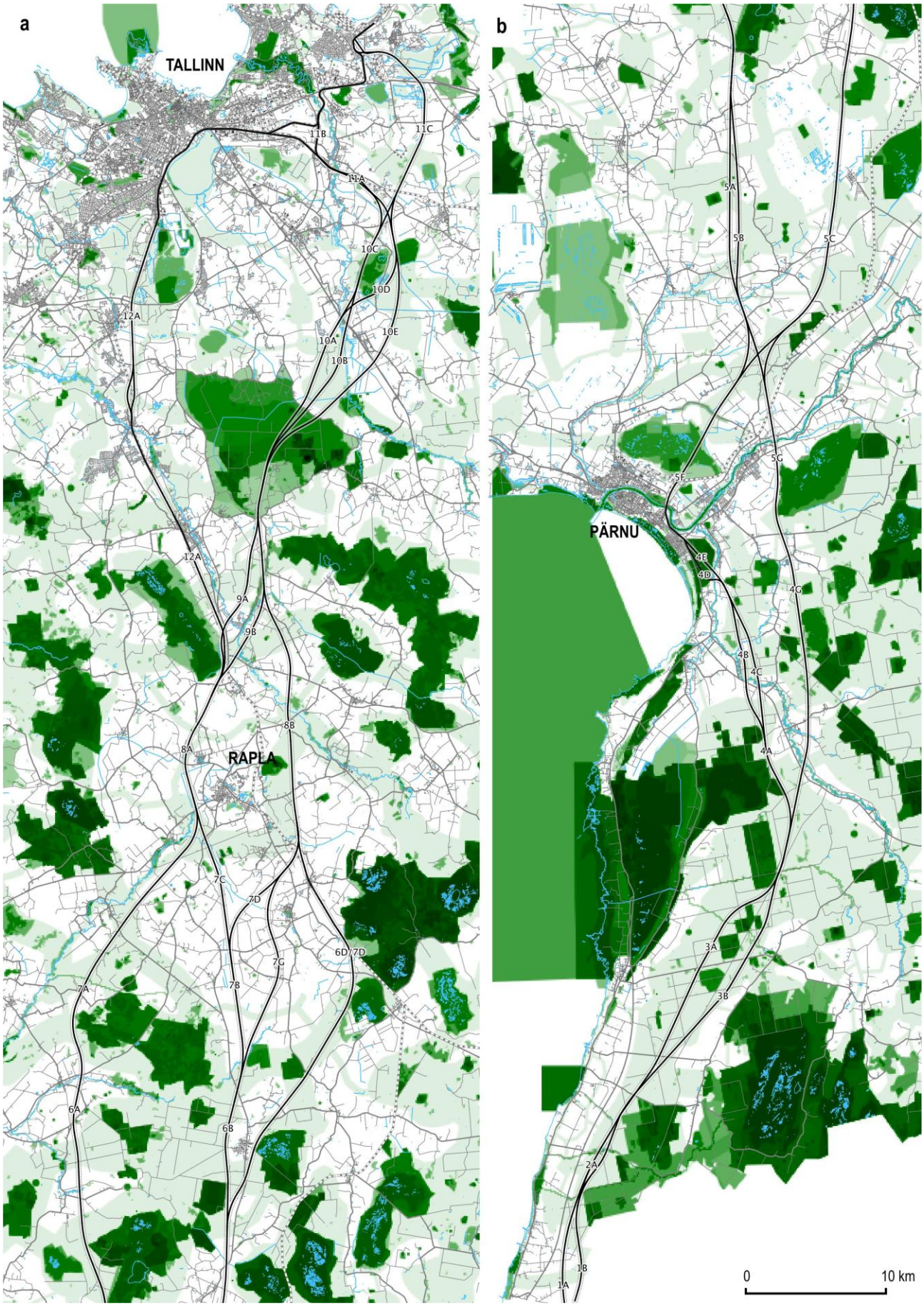
1) model of protected species (map 2) explains spatial distribution of habitats of the species, species abundance and strictness of their protection regime, based on Environment Register, field observations made during the inventory and contributed information. In result of this, strong conflicts appear on railway sections 5F, 7D and10A (see also maps 7–12 and tables 1–6);
2) model of protected areas (map 3) explains spatial distribution of protection strength based on present and planned protected areas in Environment Register. In result of this, strong conflicts appear on railway sections 4E, 4D (Natura 2000 protected habitats and Pärnu landscape reserve), 5F (Natura 2000 protected habitat and planned Rääma bog reserve) and 10A, 10B, 10E (planned Nabala landscape reserve and Pahkla landscape reserve; see also maps 7–12 and tables 1–6);
3) model of large mammals (map 4) explains complex distribution of habitat quality and moving intensity of ungulates (moose, red deer, roe deer and wild boar) and large carnivores (lynx, wolf and bear). This model denoted strongest conflicts in Rapla county and in South Pärnu county;
4) model of medium-sized mammals (map 5) explains complex distribution of habitat quality and moving intensity of common mammals lesser than roe deer and lynx, and larger than shrews, voles and mice;
5) model of bats (map 6) explains complex distribution of habitat quality and moving intensity of the 11 species of Estonian Chiropteras.

Statistical support of the original habitat models was relatively high. Area under the receiver operating characteristic curve, that characterize the relation of sensitivity and specificity of the model prediction (model credibility) were on average 0.86 (range 0.76–0.97) in cases of the particular models of 11 mammal species. Thus, we assumed high utility of the summary GIS-models that in addition to the field inventory data incorporated various other relevant data sources.

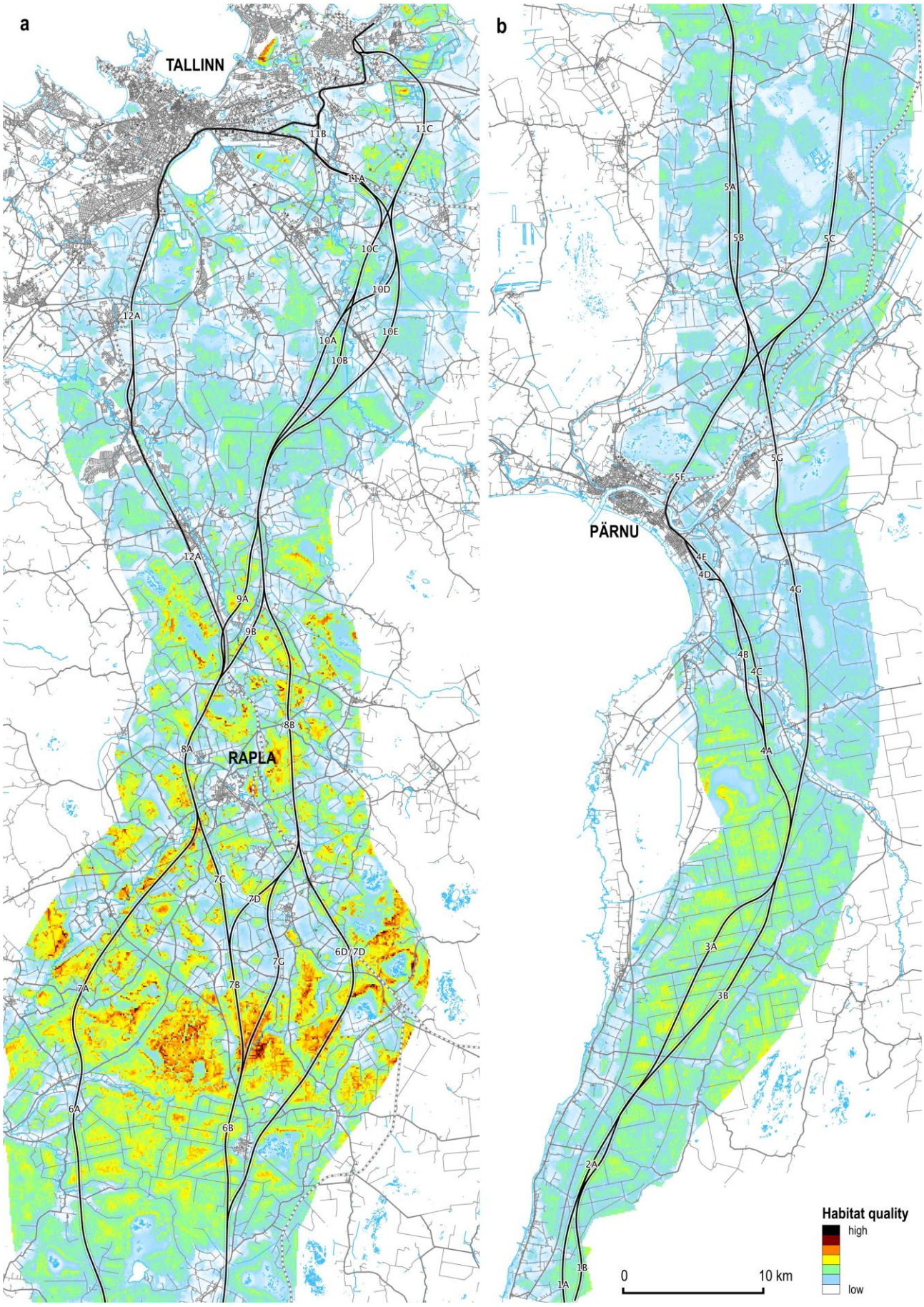
Map 2. **Summary model of species protection strictness** based on habitats registered in Environment Register, field observations during the inventory and contributed information in northern (a) and southern (b) half of the survey region. The darker the red color the larger is the number and stricter the conservation category of the species in a particulat location.



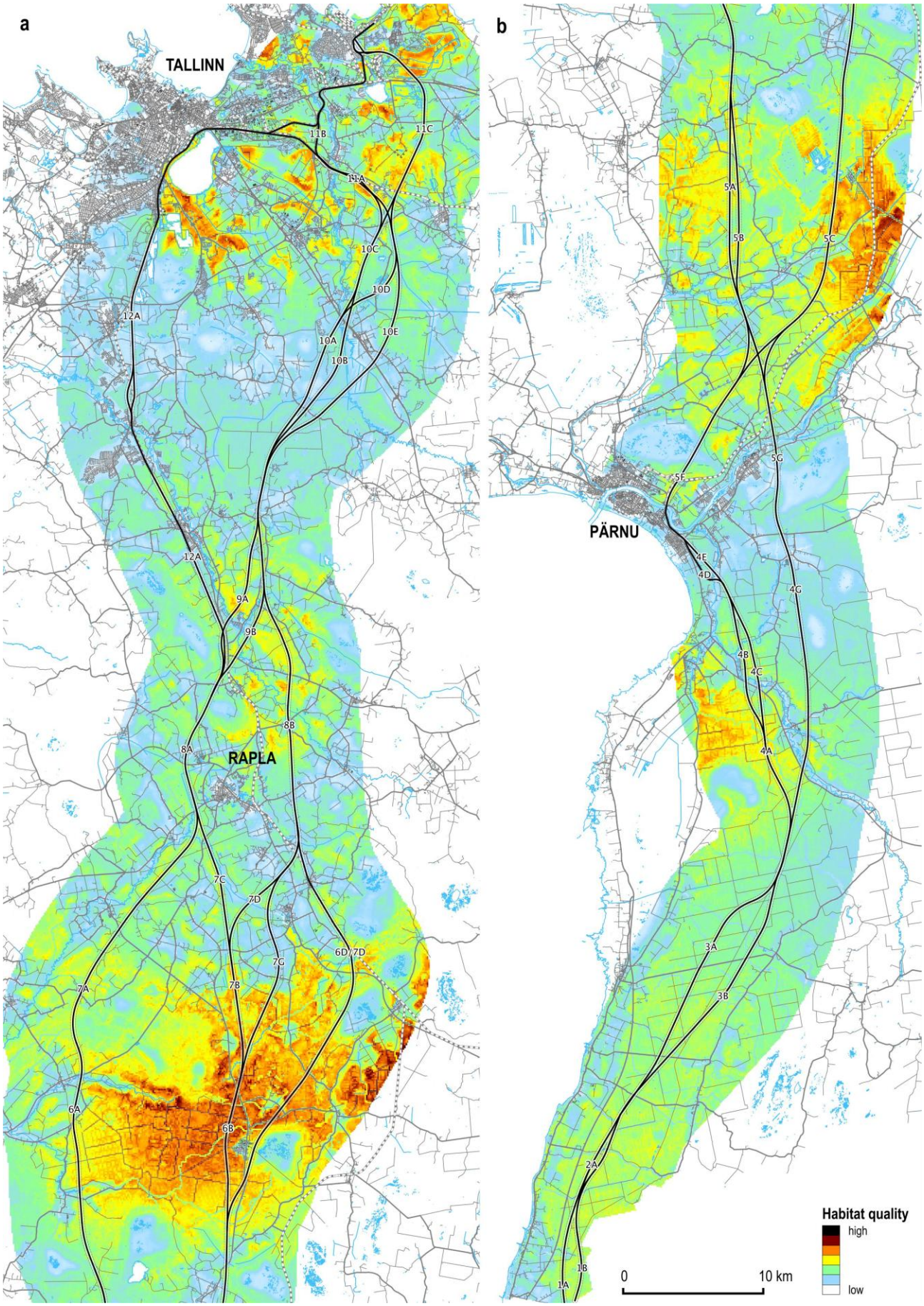
Map 3. **Summary model of area conservation strength** based on present and planned protected areas in Environment Register and weighting of those in northern (a) and southern (b) half of the survey region. The darker the green color the stronger the conservation regime of a particulat location.



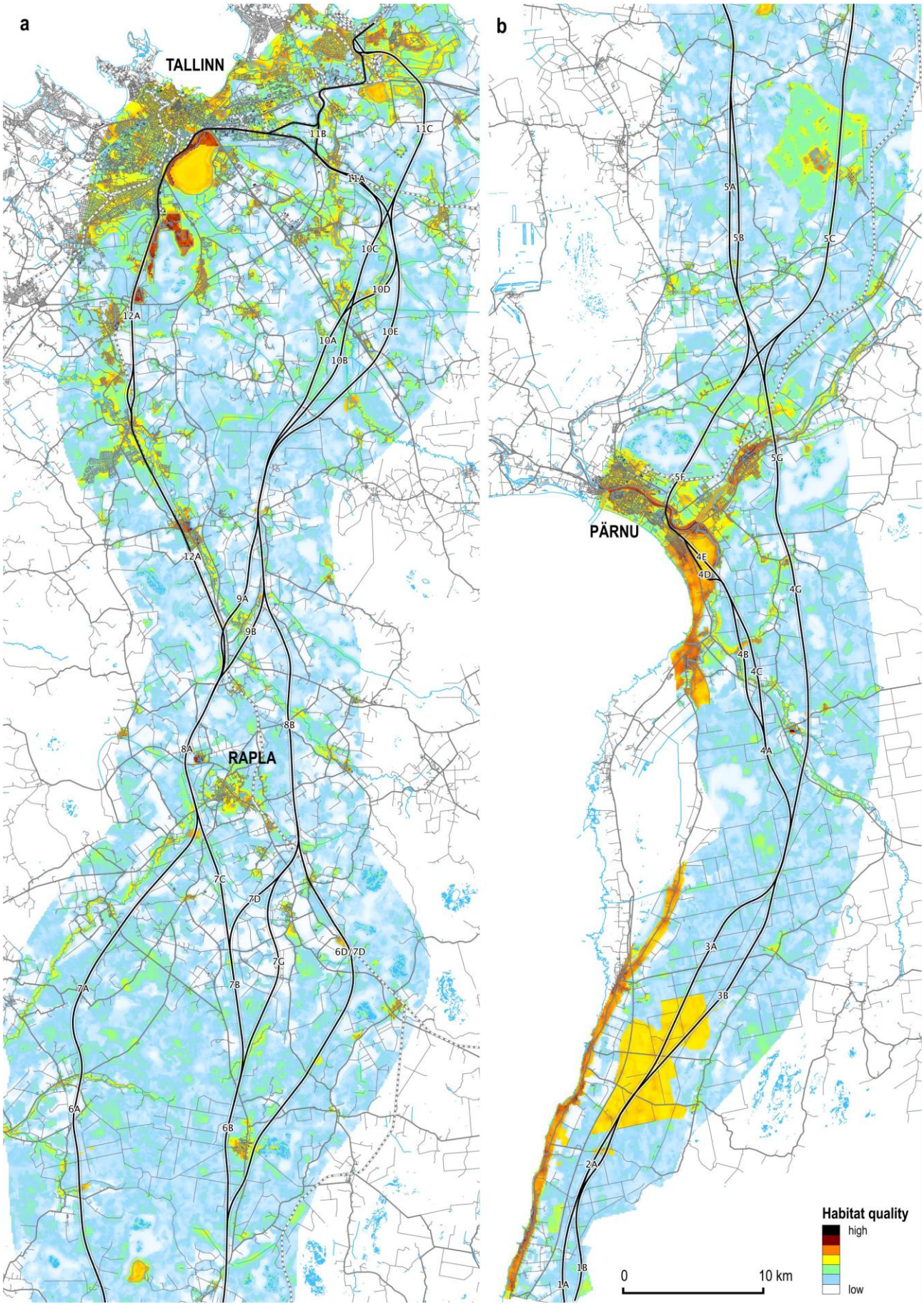
Map 4. **Summary model of large mammal habitat quality** within 5 km from the alternative railway lines in northern (a) and southern (b) half of the survey region, based on data of field inventory and State monitoring of game animals. Warm color tones denote high habitat quality, and cold tones denote low quality.



Map 5. **Summary model of medium-sized mammal habitat quality** within 5 km from the alternative railway lines in northern (a) and southern (b) half of the survey region, based on data of field inventory and State monitoring of game animals. Warm color tones denote high habitat quality, and cold tones denote low quality.



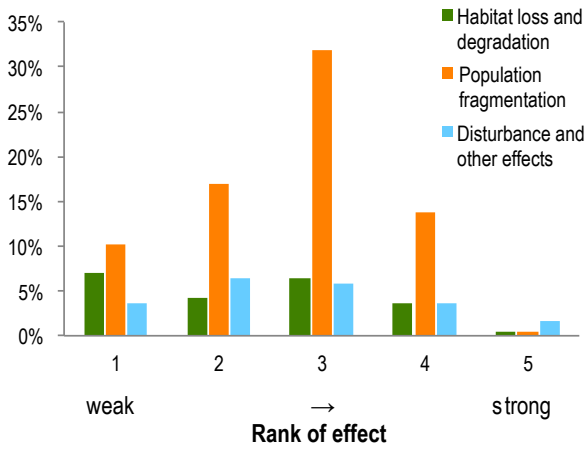
Map 6. **Summary model of bat habitat quality** within 5 km from the alternative railway lines in northern (a) and southern (b) half of the survey region, based on bat habitats registered in Environment Register and opinion of bat expert (M. Leivits and L. Lutsar). Warm color tones denote high habitat quality, and cold tones denote low quality.



Conflict sites and implications

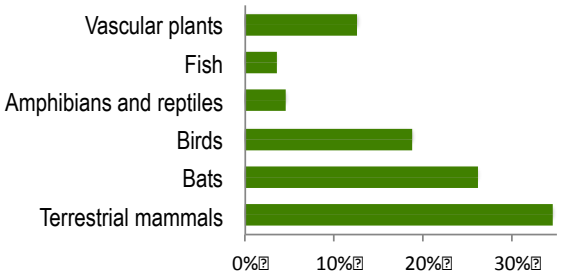
Based on the abmentioned data sources and models, 188 conflict sites appeared on the alternative railway lines (tables 1–6, maps 7–12). According to the estimated character of the effect in potential conflict sites, the predominant effect of the railway could appear on animal population connectivity at moderate severity (figure 2, tables 1–6). To retain the connectivity of large mammal populations, we recommend 20–30 passages for the ungulates and large carnivores spread from Tallinn to Ikla. The passages could be specially built ecoducts, or combined with railway bridges over rivers or lesser roads (Iuell *et al*. 2003, Klein 2010). As the railway is relatively narrow linear object, considerable direct habitat loss and degradation is not as common, but can be important locally.

Figure 2. Abundance proportion of three main types of effects in the five ranks of effect severity. The scale of the rank of effect is divided on a relative scale where value 1 denotes a presumably weak effect of the railway that could be easy to compensate, and value 5 denotes a strong and not compensatable effect.



An important group of species is terrestrial mammals (particularly the large sized), which would be affected in approximately one third of the sites of probable conflicts (figure 3). The reason is their essential, but limited mobility (compared to fledged animals), and wide range of habitat use over the group.

Figure 3. Proportion of different species groups expectedly affected in the estimated conflict sites. The likely conflicts are related to vascular plants in 33 sites, fish in 9 sites, amphibians and reptiles in 12 sites, birds in 49 sites, terrestrial mammals in 90 sites, and bats in 68 sites.



In 50 sites the impact on local species or habitats could be reduced by shifting the preliminary railway line; 59 sites could be potential for large mammal passages (ecoduct, open bank path under extended river bridge, *etc.*); and there are 27 river crossings that deserve attention as movement corridor of aquatic and terrestrial animals on the alternative railway lines. Three sites appeared where impact of the railway would be uncompensatably strong (table 7 and figure 4), and there are three major regions of complex problems:

- Tammiku nature reserve, planned Nabala landscape reserve and surrounding area in South Harju county that is mostly related to valuable forest and wetland habitats of various species – mammals, forest birds and plants, and socio-ecological attitude of the society;
- South Raplamaa that is related to large scale dispersal territory of large mammals, incl. ungulates and large carnivores;
- forest and bog landscape in surroundings of Pärnu and southwards that are related to high-quality habitats of various animals – birds, bats and terrestrial mammals.

Considering the extent of the railway project and its general impact, we bring out general recommendations of compensating measures that are not included in the following tables 1–6:

1) water regime should be preserved all around the railway, but it needs extra attention in vicinity of natural wetlands (swamps and bogs). Critical sites in respect to water regime change are shown in the maps 7–12;
2) height of the fences should be at least 2.5 m. That prevent moose, as the largest animal in Estonian fauna, but also lesser animals get into the railway corridor by jumpping over the fence;
3) medium-sized animals, with up to badger-sized body, should pass under the fence all along the railway. Exceptions may be in human settlements. It is reasonable that the fence blocks movement of only ungulates and large carnivores as those are realistic danger for high-speed rail traffic;
4) passages for amphibians, reptiles and small mammals (rodents), which are not able to climb over rails, should be constructed in every 25–50 m. The passthrough could be relatively simple – *e.g.* an open hole between sleepers, under rails, and smooth baseboard for the formating inter-sleeper gutter. Note that in addition to the general measure, there are couple of sites where amphibian moving deserves focused attention and special solution;
5) minimize construction activity in natural areas (predominantly related to forests) during the main breeding season of animals (especially birds) from April to June;
6) it is important to continue nature monitoring after the railway construction in concern of unpredictable as well as long term effects of the railway. The plan should include readiness to implement additional compensating measures where necessary.

Map 7. Probable conflict sites on the alternative railway lines. Explanation: red line and number – a conflict site listed in the adjacent table 1 (style according to rank); blue line – recommended shifting of the railway line; warm green fill on railway corridor – location for animal passthrough.

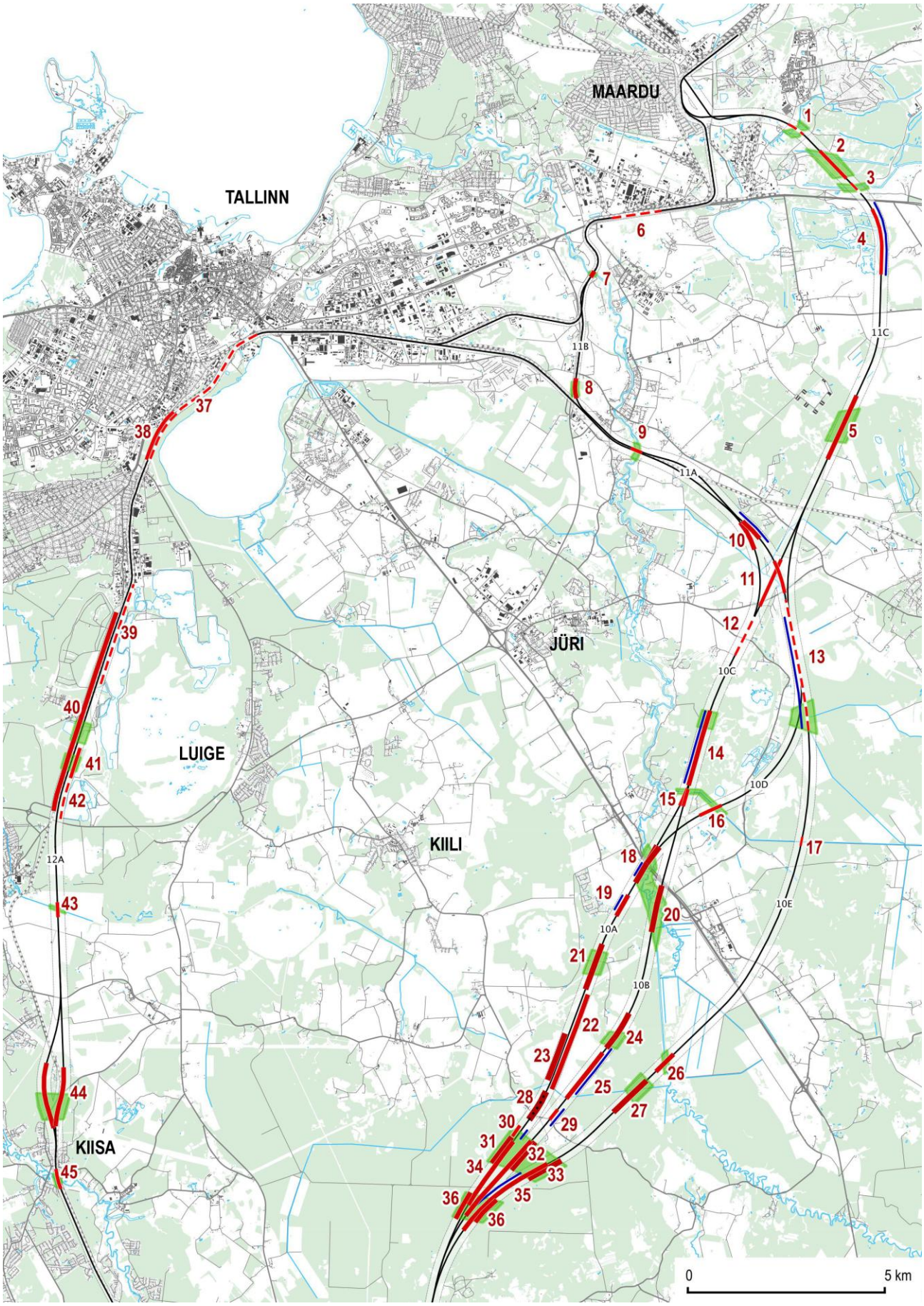


Table 1. Conflict sites depicted on the map 7 on the alternative railway lines. Relative scale of the rank: 1 – presumably weak effect of the railway that could be easy to compensate, 5 – strong and not compensatable effect.

Site	Railway section	Predicted problem for railway construction	Rank	Suggested principle of solution	Mostly affected species / groups
1	11C	Bat feeding habitat related to ponds.	1	Use a solution that retains open flight area on bat flight altitude below or above the railway. Avoid artificial illumination. Keep ponds and sparse stand between these.	Bats
2	11C	Bat feeding habitat related to ponds. Moving corridor of ungulates.	2	Use a solution that retains open flight area on bat flight altitude below or above the railway. Avoid artificial illumination. Keep ponds and sparse stand between these. Build ecoduct or other passthroug, and infrastructure that guides animals to it.	Bats, ungulates and medium-sized mammals
3	11C	Bat feeding habitat related to ponds.	1	Use a solution that retains open flight area on bat flight altitude below or above the railway. Avoid artificial illumination. Keep ponds and sparse stand between these.	Bats
4	11C	Important bat feeding habitat related to ponds.	2	Keep to east. Use a solution that retains open flight area on bat flight altitude above the railway. Avoid using artificial illumination. Keep ponds and sparse stand between these.	Bats
5	11C	Moving corridor of large mammals.	3	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Ungulates and medium-sized mammals
6	11B	Habitat of protected plants (II & III cat.) southward from the line.	1	Keep to north from the highway, and keep the railway corridor as narrow as possible.	Plants
7	11B	Rivercrossing – moving corridor of semiaquatic animals and bats, and habitat of protected fishes (III cat. spined loach and bullhead) and salmons.	3	Retain animals path on riverbanks and bat fight below and above the raiway. Avoid artificial illumination. Keep trees on riverbanks. Avoid mudflows during railway construction.	Semiaquatic animals, bats, medium-sized mammals and fishes
8	11B	Planned wildlife passthrough on the main road.	3	Coordinate activity with Estonian Road Administration.	Ungulates and medium-sized mammals
9	11A	Rivercrossing – moving corridor of semiaquatic animals and bats, and habitat of protected fishes (III cat. spined loach and bullhead) and salmons.	2	Retain animals path on riverbanks and bat fight below and/or above the railway. Avoid artificial illumination. Keep trees on riverbanks. Avoid mudflows during railway construction.	Bats, semiaquatic and medium-sized mammals, and fishes
10	11A	Nest of I cat. protected bird southward from the line.	3	Keep to north.	Bird
11	11A, 11C	High value amphibian breeding habitat related to ponds.	2	Retain the ponds, provide railway crossings for amphibians and keep the railway corridor as narrow as possible.	Amphibians
12	10C	Habitat of eurasian curlew (III cat. bird) westward from the line.	1	Keep to east and preserve grassland habitat.	Meadow birds
13	10D/10E	Bat feeding habitat related to the large ditch. Moving corridor of ungulates.	1	Keep to west and retain the large ditch and trees on the bank. Build ecoduct or other passthroug, and infrastructure that guides animals to it.	Bats, ungulates and medium-sized mammals
14	10C	High-value habitat complex – coniferous and broad leafed forest mixed with swamp meadow; small hillocks. Habitat of protected plants (III cat., orchids et al.). High-value habitat for ungulates.	3	Select other alternative, if not possible, keep to west. Build ecoduct or other passthroug, and infrastructure that guides animals to it.	Plants, ungulates and medium-sized mammals
15	10A, 10B	Bat feeding habitat related to the large ditch, forest edge and tree stripes.	2	Use a solution that retains open flight area on bat flight altitude below or above the railway. Avoid artificial illumination.	Bats
16	10D	Bat feeding habitat related to the large ditch and forest edges.	2	Use a solution that retains open flight area on bat flight altitude below or above the railway. Avoid artificial illumination.	Bats
17	10E	Bat feeding habitat related to the large ditch.	1	Use a solution that retains open flight area on bat flight altitude below or above the railway. Avoid artificial illumination.	Bats
18	10A	Rivercrossing and moving corridor of terrestrial animals.	4	Retain animal path on river banks. Keep rather to west.	Large and medium-sized mammals
19	10A	Nest of I cat. protected bird easward from the line.	3	Keep to west	Bird
20	10B	Rivercrossing and moving corridor of terrestrial animals.	4	Retain animal path on river banks and meadow.	Large and medium-sized mammals
21	10A	Moving corridor of large mammals.	4	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
22	10A	Important bat feeding habitat on bog and surrounding stands.	3	Select other alternative.	Bats
23	10A	High value bog habitat in good condition, and play ground of black grouse (III cat.)	4	Select other alternative.	Grouse, plants
24	10B	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
25	10B	Important bat feeding habitat on bog and surrounding stands.	3	Select an other alternative, if not possible, keep to east	Bats
26	10E	Bat feeding area near river, and amphibian breeding ponds.	3	Keep to west and preserve animal paths on bank, and use a bridge solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination.	Amphibians, bats, semiaquatic animals
27	10E	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
28	10A	Nest of I cat. protected bird on the line.	5	Select other alternative.	Bird
29	10B	Nest of I cat. protected bird westward from the line.	2	Keep to east	Bird
30	10A	Nest of I cat. protected bird westward from the line.	2	Keep to east	Bird
31	10A	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. carnivores)
32	10B	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. carnivores)
33	10E	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. carnivores)
34	10A, 10B	High-value forest habitat, several protected species (I-III cat.) – mostly plants and birds	3	Keep the railway corridor as narrow as possible. Preserve water regime. Use fence solution that do not limit bird moving.	Forest birds, plants
35	10E	High-value forest habitat, several protected species (I-III cat.) – mostly plants and birds	3	Keep the railway corridor as narrow as possible. Keep to west and preserve water regime. Use fence solution that do not limits bird moving.	Forest birds, plants
36	10A, 10B, 10E	Dispersal area of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. carnivores)
37	12A	Bat feeding habitat related to lake and forest.	1	Preserve forest habitat, use current railway line or stay very near to road line. Reduce artificial illumination.	Bats
38	12A	Habitat of protected plants (III cat.) on the line.	2	Keep corridor as narrow as possible and use current railway line.	Plants
39	12A	High values bat feeding area and several protected passerine birds and plants (II & III cat.) eastward from the line	1	Use the current railway line and retain water regime.	Bats, small birds
40	12A	Population of I cat. protected amphibian mostly east but also westward from the line.	3	Preserve water regime and provide special passthrough for toad and other amphibian moving	Amphibians
41	12A	Moving corridor of large ungulates.	2	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
42	12A	Bat feeding habitat related to ponds eastward from line.	1	Preserve forest habitat and water regime. Avoid artificial illumination.	Bats
43	12A	Bat feeding habitat and flying corridor on the large ditch.	2	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Keep trees on ditch banks and on nearby meadows.	Bats
44	12A	Moving corridor of large ungulates.	3	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
45	12A	Bat feeding habitat and flying corridor related to river and nearby wooded meadows.	2	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Keep old-riverbeds, trees on river banks and on nearby meadows.	Bats

Map 8. Probable conflict sites on the alternative railway lines. Explanation: red line and number – a conflict site listed in the adjacent table 2 (style according to rank); blue line – recommended shifting of the railway line; warm green fill on railway corridor – location for animal passthrough.

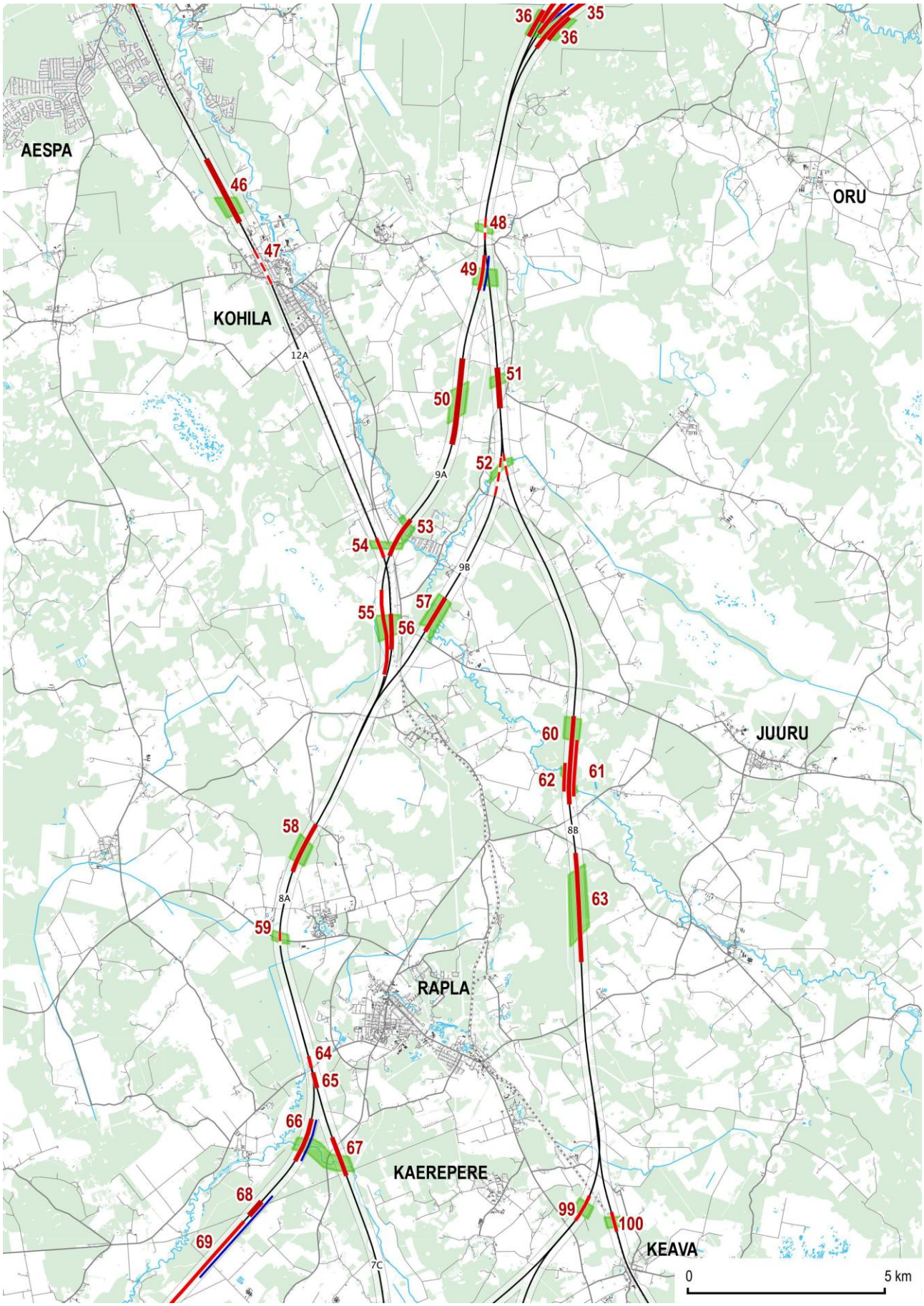


Table 2. Conflict sites depicted on the map 8 on the alternative railway lines. Relative scale of the rank: 1 – presumably weak effect of the railway that could be easy to compensate, 5 – strong and not compensatable effect.

Site	Railway section	Predicted problem for railway construction	Rank	Suggested principle of solution	Mostly affected species / groups
35	10E	High-value forest habitat, several protected species (I-III cat.) – mostly plants and birds	3	Keep the railway corridor as narrow as possible. Keep to west and preserve water regime. Use fence solution that do not limits bird moving.	Forest birds, plants
36	10A, 10B, 10E	Dispersal area of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. carnivores)
46	12A	Moving corridor of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
47	12A	Bat feeding habitat and amphibian habitats related to the river and flood.	1	Avoid artificial illumination and preserve water regime.	Bats, amphibians
48	9A/9B	Bat feeding habitat and flying corridor related to stream and nearby wooded meadows.	1	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Keep trees on river banks and on nearby meadows.	Bats
49	9A	Amphibian breeding ponds westward from the line.	2	Keep to east and provide railway crossing for amphibians.	Amphibians
50	9A	Moving corridor of large mammals.	4	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
51	9B	Moving corridor of large mammals.	4	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
52	9B, 8B	Bat feeding habitat and flying corridor related to stream and nearby wooded meadows.	1	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Keep trees on riverbanks and on nearby meadows.	Bats
53	9A	Bat feeding habitat and flying corridor related to river and nearby wooded meadows.	3	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Keep trees on riverbanks and on nearby meadows.	Bats
54	12A	Bat feeding habitat related to forest edge.	2	Keep corridor as narrow as possible and use current railway line. Provide wooden stripes that guide bats over railway.	Bats
55	9A	Bog that is the only habitat of a bog butterfly *Clossiana frigga* in Estonia, westward from the line, and moving corridor of large mammals.	3	Preserve water regime. Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Insects, large and medium-sized mammals
56	12A	Moving corridor of large mammals.	3	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
57	9B	River and meadow –bat feeding habitat, and movement corridor of large mammals.	3	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Keep trees on riverbanks and on nearby meadows. Provide under bridge passthrough for large and medium sized mammals and semiaquatic animals, and construct infrastructure that guides animals there.	Semiaquatic animals, bats
58	8A	Moving corridor of large mammals.	3	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
59	8A	Bat feeding habitat on the large ditch.	1	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination.	Bats
60	8B	Dispersal area of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
61	8B	High-value wetland, habitat for III cat. protected plants (Early Marsh Orchid et al.) eastward from the line.	2	Keep corridor as narrow as possible, preserve water regime, and keep to west.	Plants
62	8B	Bat feeding habitat and moving corridor on the river and surrounding woodland.	2	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Preserve trees on riverbanks.	Bats
63	8B	Dispersal area of large mammals.	3	Build one wide or two ordinary ecoducts or an other passthroughs, and infrastructure that guides animals to those.	Large and medium-sized mammals
64	8A	Moving corridor of semiaquatic animals on banks of the natural stream	2	Preserve natural banks of the stream as passthrough for semiaquatic animals	Medium-sized mammals, amphibians
65	7C	Strong population of Fragrant Orchid (III cat. plant) on meadow, on the line and eastward from it.	3	Keep corridor as narrow as possible.	Plants
66	7A	Bat feeding habitat and moving corridor on the stream and in surrounding forests. Moving corridor of ungulates.	3	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Preserve forest habitat. Build ecoduct or an other passthrough, and infrastructure that guides animals to it. Keep to east.	Bats, ungulates, semiaquatic animals
67	7C	Moving corridor of ungulates and natural stream.	3	Build bridge with animals path on the riverside meadow, and infrastructure that guides animals to it.	Ungulates, semiaquatic animals
68	7A	Habitat of *a* II cat. protected plant and high value calcareous meadow.	4	Keep west or strongly to east, retain water regime and preserve the wooded meadow habitat.	Plants
69	7A	High quality ungulate habitat and unfound nest of a I cat. protected bird westward from the line.	2	Keep to east, out from forest.	Ungulates, bird
99	7D	Moving corridor of ungulates.	2	Build ecoduct and infrastructure that guides animals to it	Large and medium-sized mammals
100	6D/7D	Moving corridor of ungulates.	2	Build ecoduct and infrastructure that guides animals to it	Large and medium-sized mammals

Map 9. Probable conflict sites on the alternative railway lines. Explanation: red line and number – a conflict site listed in the adjacent table 3 (style according to rank); blue line – recommended shifting of the railway line; warm green fill on railway corridor – location for animal passthrough.

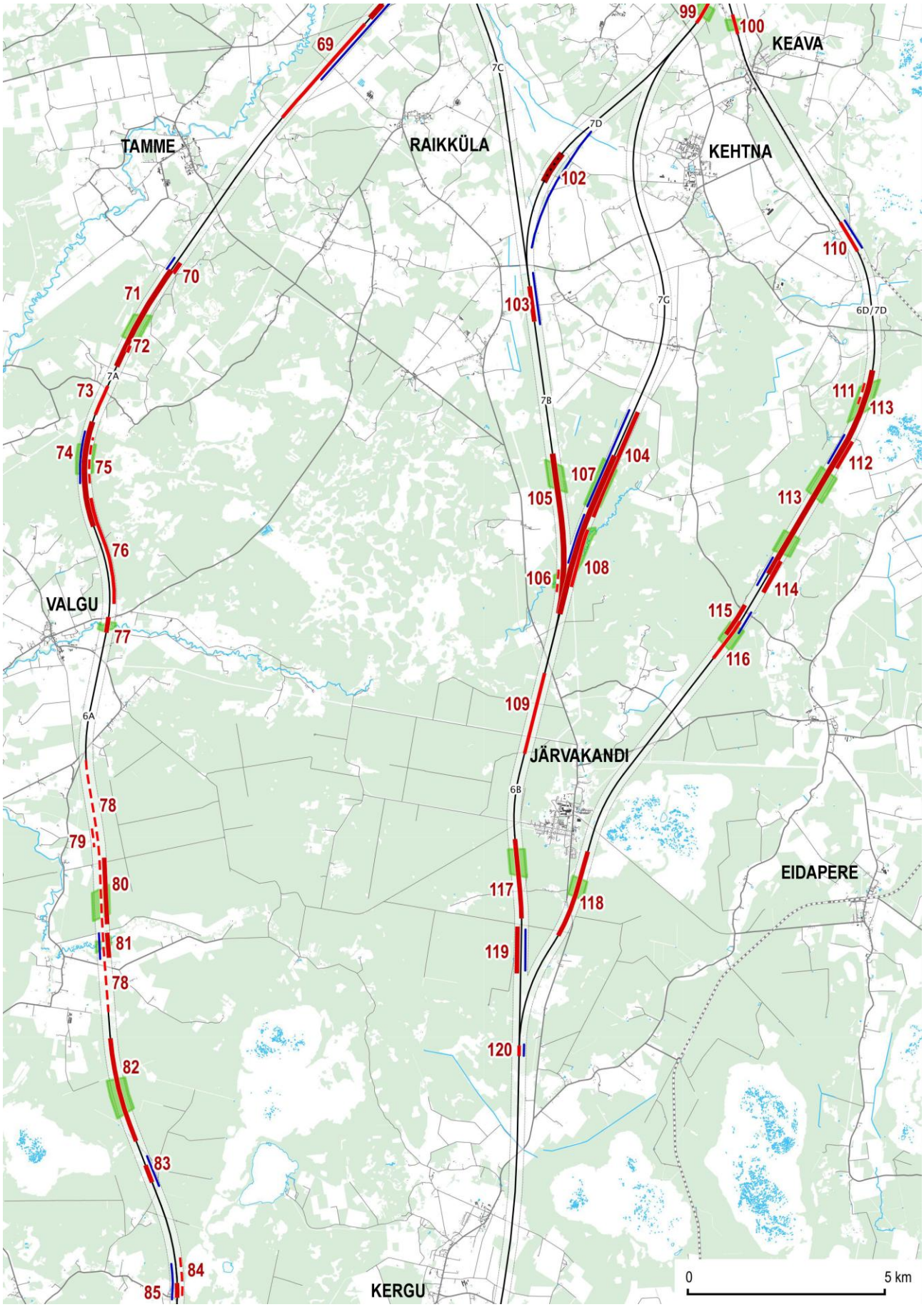


Table 3. Conflict sites depicted on the map 9 on the alternative railway lines. Relative scale of the rank: 1 – presumably weak effect of the railway that could be easy to compensate, 5 – strong and not compensatable effect.

Site	Railway section	Predicted problem for railway construction	Rank	Suggested principle of solution	Mostly affected species / groups
69	7A	High quality ungulate habitat and unfound nest of I cat. protected bird westward from the line.	2	Keep to east, out from forest.	Ungulates, bird
70	7A	Several protected plants and fungi (I & II cat.) in forest, eastward from the line.	3	Keep to west, and retain water regime.	Plants, fungi
71	7A	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
72	7A	Stream of salmons	2	Avoid mudflow during railway construction.	Fishes
73	7A	Habitat of III cat. protected plants (fragrant orchid and other orchids) on the calcareous meadow under power-lines crossed with the railway line.	2	Keep corridor as narrow as possible.	Plants
74	7A	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
75	7A	Habitat of III cat. protected plants eastward from the line.	1	Retain water regime and keep west	Plants
76	7A	High-value forest area. Habitat for several II & III cat. birds.	2	Keep corridor as narrow as possible and preserve water regime.	Forest birds
77	7A	Bat feeding habitat and moving corridor on the river and nearby trees.	3	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Preserve trees on river banks. Retain bank path for semiaquatic animals.	Bats, semiaquatic animals
78	6A	Two unfound nest of I cat. protected bird probably on the line.	1	Reduce construction activity during nesting season or select other alternative.	Bird
79	6A	Bat flying corridor related to the natural stream.	1	Retain the wooden stripe.	Bats
80	6A	Dispersal area of large mammals.	3	Build wide ecoduct and infrastructure that guides animals to it	Large and medium-sized mammals (incl. large carnivores)
81	6A	Bat feeding habitat along the stream and on wooded meadows in surroundings. Animals moving corridor near the stream.	3	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Preserve trees along the stream. Preserve moving path for semiaquatic animals near the stream. Keep to east.	Bats, semiaquatic animals
82	6A	Dispersal area of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
83	6A	Bat feeding habitat related to the forest swamp on the line.	3	Preserve forest habitat, keep corridor as narrow as possible, and keep to east.	Bats
84	6A	Habitat of common spotted-orchid (III cat. protected plant) eastward from the line. High-value swamp habitat.	1	Preserve water regime. Keep to west.	Plants
85	6A	Bat feeding habitat related to ponds on the line	3	Retain the ponds and trees nearby. Keep corridor as narrow as possible. If possible, keep to west.	Bats
99	7D	Moving corridor of ungulates.	2	Build ecoduct and infrastructure that guides animals to it	Large and medium-sized mammals
100	6D/7D	Moving corridor of ungulates.	2	Build ecoduct and infrastructure that guides animals to it	Large and medium-sized mammals
101	5A/5B	Natural stream and bat feeding habitat.	2	Retain stream bank path for medium-sized animals movement. Retain the trees along the stream, and provide bats' fight over the railway.	Bats, semiaquatic animals
102	7D	Nest of I cat. protected bird on the line.	5	select an other alternative or keep far to east. Reduce construction activity during nesting season.	Bird
103	7B	High-quality amphibian breeding habitat related to ponds.	3	Retain the ponds, provide railwaycrossing for amphibians and keep the railway corridor as narrow as possible. Keep to east.	Amphibians
104	7G	Habitat of I cat. protected birds rather eastward from the line. High-value swamp habitat patches dispersedly on the line.	3	Keep to west and preserve water regime.	Birds
105	7B	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
106	7B	Bat feeding habitat along the stream.	1	Use a solution that retains open flight area on bat flight altitude below or above the railway. Avoid artificial illumination.	Bats
107	7G	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
108	7G	II cat. bird habitat eastward from the line, and bat feeding habitat along the stream.	2	Keep west and reduce noise. Avoid construction activity during breeding season. Keep flood habitat along the stream.	Bird, bats
109	6B	Feeding ground of I cat. protected bird on the line.	2	Preserve water regime and keep corridor as narrow as possible.	Bird
110	6D/7D	Bat nesting and feeding habitat in manor park and bordering forest, westward from the line.	2	Preserve the woodland and keep corridor as narrow as possible. Keep to east and avoid artificial illumination.	Bats
111	6D/7D	III cat. protected plants westward from the line.	1	Retain water regime and keep corridor as narrow as possible.	Plants
112	6D/7D	Important bat habitat in swamp on the line.	3	Keep to west.	Bats
113	6D/7D	Dispersal area of large mammals. High-quality habitat for a I cat. protected bird.	4	Build three wide ecoducts or other passthroughs, and infrastructure that guides animals to those. Keep railway corridor as narrow as possible.	Large and medium-sized mammals (incl. large carnivores), bird
114	6D/7D	Important bat habitat in swamp on the line. High-value swamp habitat.	3	Keep to west and retain water regime.	Bats
115	6D/7D	Habitat of II cat. protected bird westward from the line.	3	Keep to east and reduce noise. Avoid construction activity during breeding season.	Bird
116	6D/7D	Moving corridor of large mammals.	2	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
117	6B	Moving corridor of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
118	6D/7D	Moving corridor of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
119	6B	II cat. protected bird habitat westward from the line.	3	Keep to east and reduce noise. Avoid construction activity during breeding season.	Bird
120	5C	Bat habitat in swamp on the line.	2	Keep to east.	Bats

Map 10. Probable conflict sites on the alternative railway lines. Explanation: red line and number – a conflict site listed in the adjacent table 4 (style according to rank); blue line – recommended shifting of the railway line; warm green fill on railway corridor – location for animal passthrough.

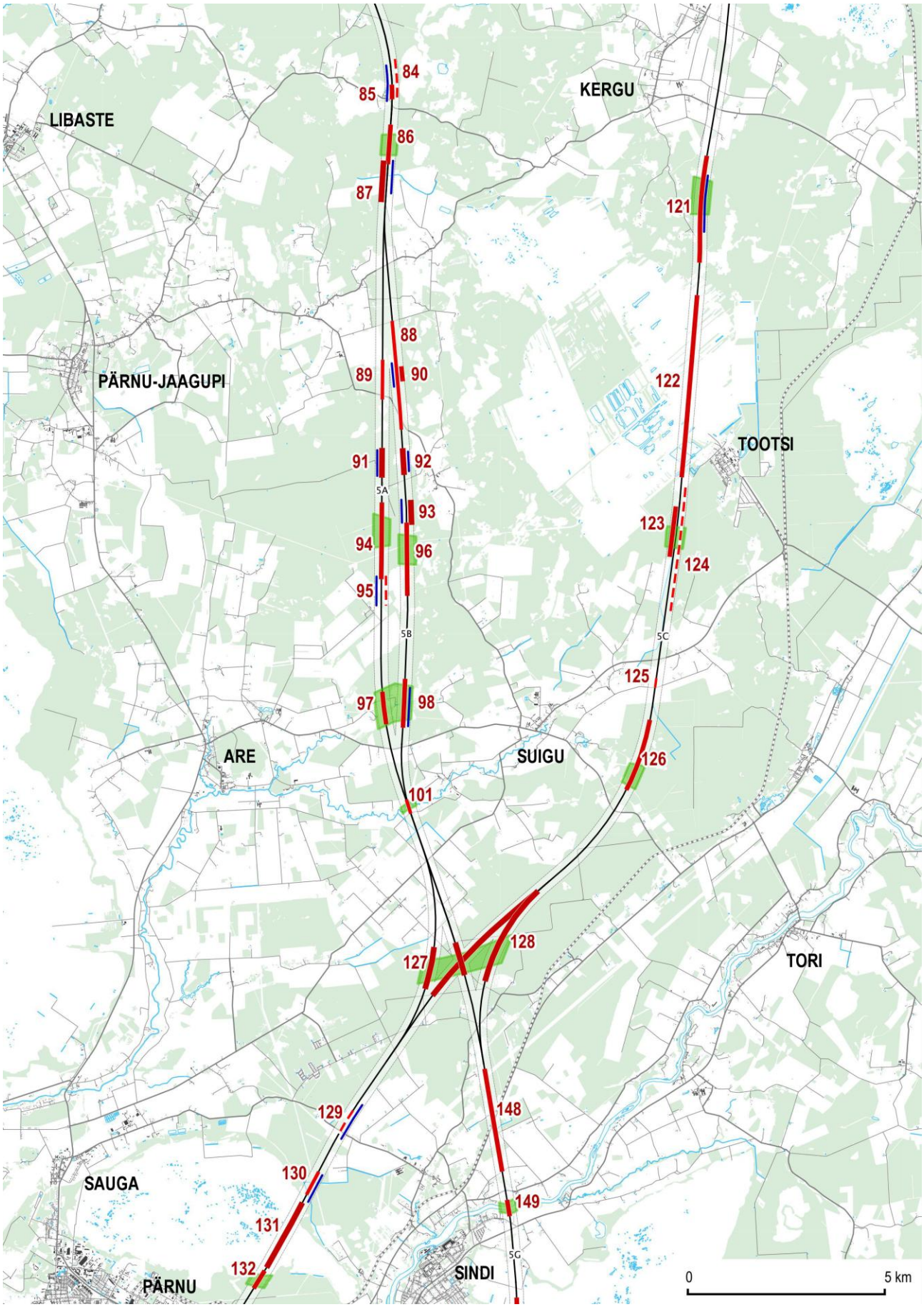


Table 4. Conflict sites depicted on the map 10 on the alternative railway lines. Relative scale of the rank: 1 – presumably weak effect of the railway that could be easy to compensate, 5 – strong and not compensatable effect.

Site	Railway section	Predicted problem for railway construction	Rank	Suggested principle of solution	Mostly affected species / groups
84	6A	Habitat of common spotted-orchid (III cat. protected plant) eastward from the line. High-value swamp habitat.	1	Preserve water regime. Keep to west.	Plants
85	6A	Bat feeding habitat related to ponds on the line	3	Retain the ponds and trees nearby. Keep corridor as narrow as possible. If possible, keep to west.	Bats
86	6A	Moving corridor of large mammals.	3	Build wide ecoduct and infrastructure that guides animals to it	Large and medium-sized mammals (incl. large carnivores)
87	6A	Bat feeding habitat on the large ditch and meadows nearby.	4	Keep to east and preserve trees. Keep corridor as narrow as possible.	Bats
88	5B	Feeding ground of I cat. protected bird on the line.	2	Preserve water regime.	Birds
89	5A	Habitat of II cat. protected plant on the line.	2	Keep corridor as narrow as possible and retain water regime.	Plants
90	5B	Bat feeding habitat on forest swamp, on the line.	3	Preserve habitat, retain water regime and keep to west.	Bats
91	5A	Nest of I cat. protected bird eastward from the line.	4	Keep to west and reduce construction activity during breeding season.	Bird
92	5B	Nest of I cat. protected bird westward from the line.	4	Keep to east and reduce construction activity during breeding season.	Bird
93	5B	Nest of I cat. protected bird eastward from the line.	4	Keep to west and reduce construction activity during breeding season.	Bird
94	5A	Dispersal area of large mammals.	3	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
95	5A	Valuable swamp forest habitat eastward from the line	1	Keep to west and retain water regime.	Plants
96	5B	Dispersal area of large mammals.	3	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
97	5A	Natural stream and important bat feeding habitat.	3	Retain stream bank path for medium-sized animals movement. Retain the wood stripes on the meadow, and use solution that provide bat fight over the railway.	Bats, semiaquatic animals
98	5B	Natural stream and important bat feeding habitat.	3	Retain stream bank path for medium-sized animals movement. Retain the wood stripes on the meadow, and use solution that provide bat fight over the railway. Keep to east.	Bats, semiaquatic animals
101	5A/5B	Natural stream and bat feeding habitat.	2	Retain stream bank path for medium-sized animals movement. Retain the trees along the stream, and provide bats' fight over the railway.	Bats, semiaquatic animals
121	5C	Dispersal area of large mammals, and feeding ground of I cat protected bird on forest ditches. Habitat of black woodpecker.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it. Preserve water regime. Keep to east.	Large and medium-sized mammals (incl. large carnivores), and Birds.
122	5C	Important bat feeding habitat related to ponds and trees, and important habitat for common crane, mostly westward from the line.	3	Reduce noise and preserve water regime. Keep wooden stripes to provide bats flying corridors. Use measures to prevent cranes moving to railway and fences.	Bats, crane
123	5C	Moving corridor of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
124	5C	Unfound nest of I cat. protected bird probably on line.	1	Reduce construction activity during nesting season or select an other alternative.	Bird
125	5C	Natural stream – moving path of semiaquatic animals.	1	Preserve bank path for medium-sized animals. Keep trees on stream banks.	Semiaquatic animals
126	5C	Dispersal area of large mammals.	3	Build wide ecoduct and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
127	5A	Moving corridor of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
128	5C	Moving corridor of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
129	5F	Bat feeding habitat along the line and on surrounding grassland.	1	Keep to east.	Bats
130	5F	Nest of I cat. protected bird westward from the line. Habitat of *Thalictrum lucidum* (III cat. plant) on the line.	2	Keep rather east, keep corridor as narrow as possible, preserve water regime.	Bird, plants
131	5F	High-quality bog habitat, several protected birds (II & III cat.) and ungulates moving paths along the line.	4	Preserve water regime, reduce noise, keep corridor as narrow as possible.	Wetland birds, undulates, bog plants
132	5F	Moving corridor of large mammals along bog border. High-quality habitat for a I cat. protected bird.	3	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Ungulates and medium-sized mammals, bird
148	5G	Important bat feeding and nesting habitat in surrounding meadows and forests.	3	Avoid artificial illumination, keep tree stripes and provide bat flight above the railway.	Bats
149	5G	Rivercrossing – bat feeding habitat and moving corridor, and III cat. protected fishes (Spined loach and european bullhead) and salmons.	3	Provide bats' fight below (or above) the railway bridge. Minimize artificial illumination. Keep trees on riverbanks, Provide animals' path on river banks. Avoid mudflows during railway construction.	Bats, semiaquatic animals, fishes

Map 11. Probable conflict sites on the alternative railway lines. Explanation: red line and number – a conflict site listed in the adjacent table 5 (style according to rank); blue line – recommended shifting of the railway line; warm green fill on railway corridor – location for animal passthrough.

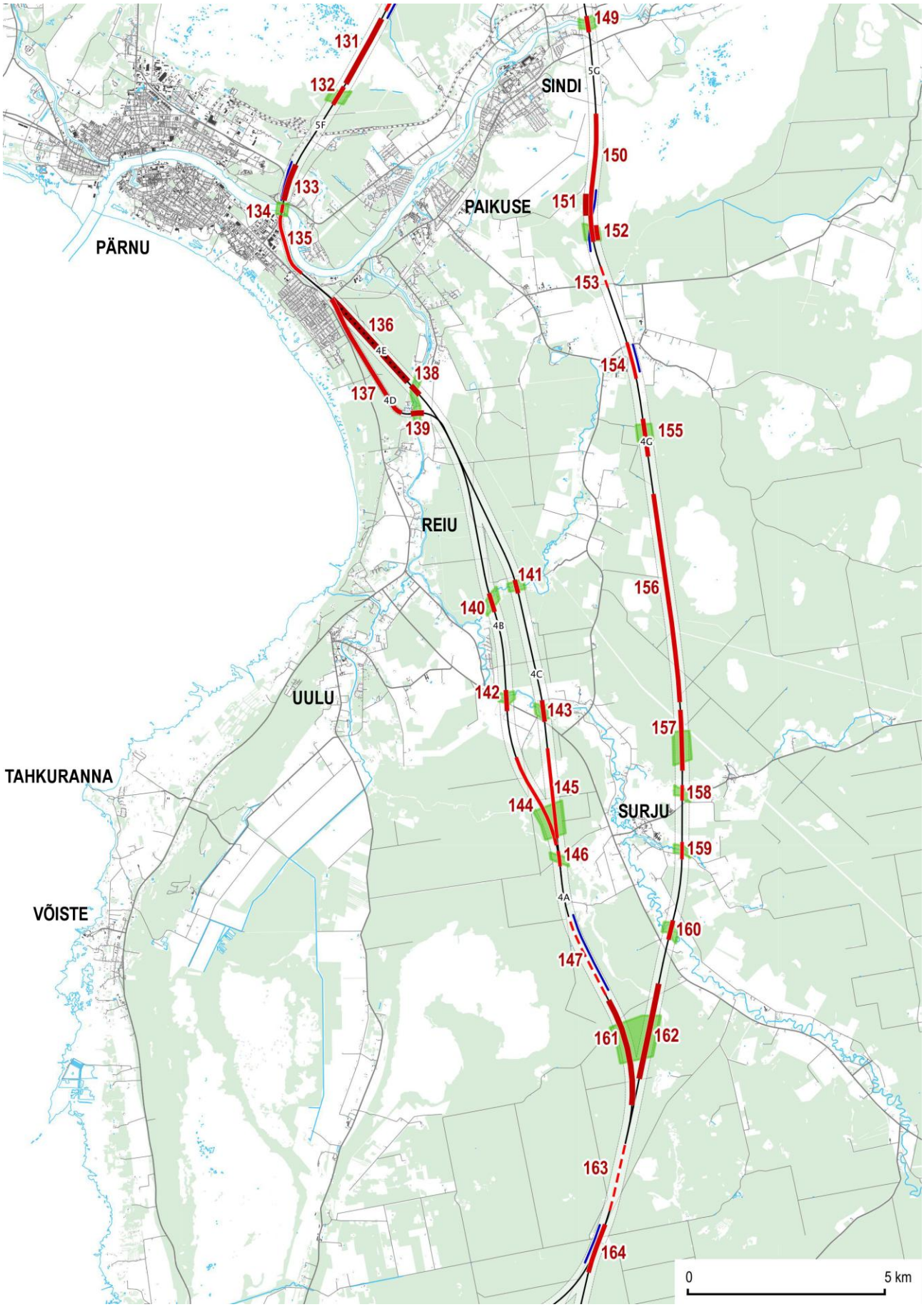


Table 5. Conflict sites depicted on the map 11 on the alternative railway lines. Relative scale of the rank: 1 – presumably weak effect of the railway that could be easy to compensate, 5 – strong and not compensatable effect.

Site	Railway section	Predicted problem for railway construction	Rank	Suggested principle of solution	Mostly affected species / groups
131	5F	High-quality bog habitat, several protected birds (II & III cat.) and ungulates moving paths along the line.	4	Preserve water regime, reduce noise, keep corridor as narrow as possible.	Wetland birds, undulates, bog plants
132	5F	Moving corridor of large mammals along bog border. High-quality habitat for a I cat. protected bird.	3	Build ecoduct or other passthrough, and infrastructure that guides animals to it.	Ungulates and medium-sized mammals, bird
133	5F	Several protected plants (III cat.) and old-growth broad-leafed mixed forest. Protected *Gladiolus imbricatus* (II cat. plant) under the high-voltage power line. High-quality habitat for a I cat. protected bird.	4	Keep to west and use the current railway line. Preserve the forest habitat and water regime.	Plants, bird
134	5F	Rivercrossing – bat feeding habitat and III cat. protected fishes (Spined loach and european bullhead) and salmons.	2	Provide bats' fight below (or above) the railway bridge. Minimize artificial illumination. Keep trees on riverbanks. Avoid mudflows during railway construction.	Bats, fishes
135	5F	Bat feeding habitat along wooded riverbank.	2	Use the current railway line and keep tree lines and groups.	Bats
136	4E	Many protected forest birds (III cat.), a lizard (II cat.), bat nesting and feeding habitat and high-value old-growth forest habitats. High-quality habitat for a I cat. protected bird.	5	Use the old railway corridor, keep corridor as narrow as possible, preserve forest habitats. Provide passthrough for small terrestrial vertebrates (incl. lizards) and secure lizard population sustainability during railway construction.	Forest birds, lizard, bats, birds
137	4D	Many protected forest birds (III cat.), a lizard (II cat), bat nesting and feeding habitat and high-value old-growth forest habitats. High-quality habitat for a I cat. protected bird.	3	Keep corridor as narrow as possible, preserve forest habitats. Provide passthrough for small terrestrial vertebrates (incl. lizards) and secure lizard population sustainability during railway construction.	Forest birds, lizard, bats, birds
138	4E	Rivercrossing – bat feeding habitat and moving area of ungulates.	4	Provide passthrough for large mammals and semiaquatic animals, and infrastructure that guides animals to it. Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination.	Bats, ungulates, medium-sized mammals
139	4D	Rivercrossing – bat feeding habitat and moving area of ungulates. III cat. protected fishes (Spined loach and european bullhead) and salmons.	4	Provide passthrough for large mammals and semiaquatic animals, and infrastructure that guides animals to it. Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Avoid mudflows during railway construction.	Bats, ungulates, medium-sized mammals
140	4B	Natural stream and important bat feeding habitat.	3	Retain stream bank path for medium-sized animals movement. Retain the trees along river bank, and use solution, that provide bat fight above or below the railway.	Bats, semiaquatic animals
141	4C	Natural stream and importand bat feeding habitat.	3	Retain stream bank path for medium-sized animals movement. Retain the trees along river bank, and use solution, that provide bat fight above or below the railway.	Bats, semiaquatic animals
142	4B	Rivercrossing and importand bat feeding habitat.	3	Retain river bank path for medium-sized animals movement. Retain the trees along river bank, and use solution, that provide bat fight above or below the railway.	Bats, semiaquatic animals
143	4C	Rivercrossing and importand bat feeding habitat.	3	Retain river bank path for medium-sized animals movement. Retain the trees along river bank, and use solution, that provide bat fight above or below the railway.	Bats, semiaquatic animals
144	4B	Dispersal area of large mammals.	2	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
145	4C	Dispersal area of large mammals.	2	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
146	4A	Natural stream	2	Provide passthrough for semiaquatic animals.	Semiaquatic animals
147	4A	II cat. protected bird habitat westward from the line.	1	Keep to east and reduce noise. Avoid construction activity during breeding season.	Bird
149	5G	Rivercrossing – bat feeding habitat and moving corridor, and III cat. protected fishes (Spined loach and european bullhead) and salmons.	3	Provide bats' fight below (or above) the railway bridge. Minimize artificial illumination. Keep trees on riverbanks, Provide animals' path on river banks. Avoid mudflows during railway construction.	Bats, semiaquatic animals, fishes
150	4G	Vicinity of valuable bog habitat of several protected birds (I, II and III cat.) eastward from the line. High-quality habitat for a I cat. protected bird.	3	Preserve water regime and reduce noise. Keep corridor as narrow as possible.	Birds
151	4G	Highly valuable meadow in contest of South-West mainland Estonia, and protected plants (III cat.) on the line.	4	Keep to east, retain water regime, keep corridor as narrow as possible or select other alternative.	Plants
152	4G	Moving corridor of ungulates near wetland edge.	3	Keep to west and build wide ecoduct or other passthrough and infrastructure that guides animals to it. Preserve animals' path along wetland border.	Ungulates and medium-sized mammals
153	4G	Habitat of *Epipactis helleborine* (III cat. plant) around the line.	1	Keep corridor as narrow as possible, and retain water regime.	Plant
154	4G	Bat feeding habitat related to the stream and surrounding trees, westward from the line.	2	Keep to east and retain trees.	Bats
155	4G	Moving corridor of large mammals.	3	Build ecoduct or an other passthrough, and infrastructure that guides animals to it.	Ungulates and medium-sized mammals
156	4G	II and III cat. protected birds habitats both side of the line.	3	Reduce noise, use lower fences to provide moving of the birds over the railway. Avoid construction activity during breeding season.	Birds
157	4G	Dispersal area of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
158	4G	Bat feeding habitat and moving corridor on the stream and in surrounding trees.	2	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Retain trees along the stream. Provide animal path on the stream banks.	Bats, semiaquatic animals
159	4G	Bat feeding habitat and moving corridor on the stream and in surrounding trees.	2	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Retain trees along the stream. Provide animal path on the stream banks.	Bats, semiaquatic animals
160	4G	Rivercrossing – bat feeding habitat and moving corridor on the river, surrounding meadows, and around trees on river banks.	3	Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Retain trees along the stream. Provide animal path on the stream banks.	Bats, semiaquatic animals
161	4A	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
162	4G	Dispersal area of large mammals.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
163	3A/3B	Habitat of II cat. protected bird westward from the line.	1	Reduce noise, use lower fences to provide moving of the bird over the railway. Avoid construction activity during breeding season.	Bird
164	3A/3B	Old-growth stand eastward from the line, and important bat feeding and nesting habitat related to the stream and old forest. Stream of salmons.	3	Keep to west and keep corridor as narrow as possible. Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Avoid mudflow during railway construction.	Bats, salmons, old forest species

Map 12. Probable conflict sites on the alternative railway lines. Explanation: red line and number – a conflict site listed in the adjacent table 6 (style according to rank); blue line – recommended shifting of the railway line; warm green fill on railway corridor – location for animal passthrough.

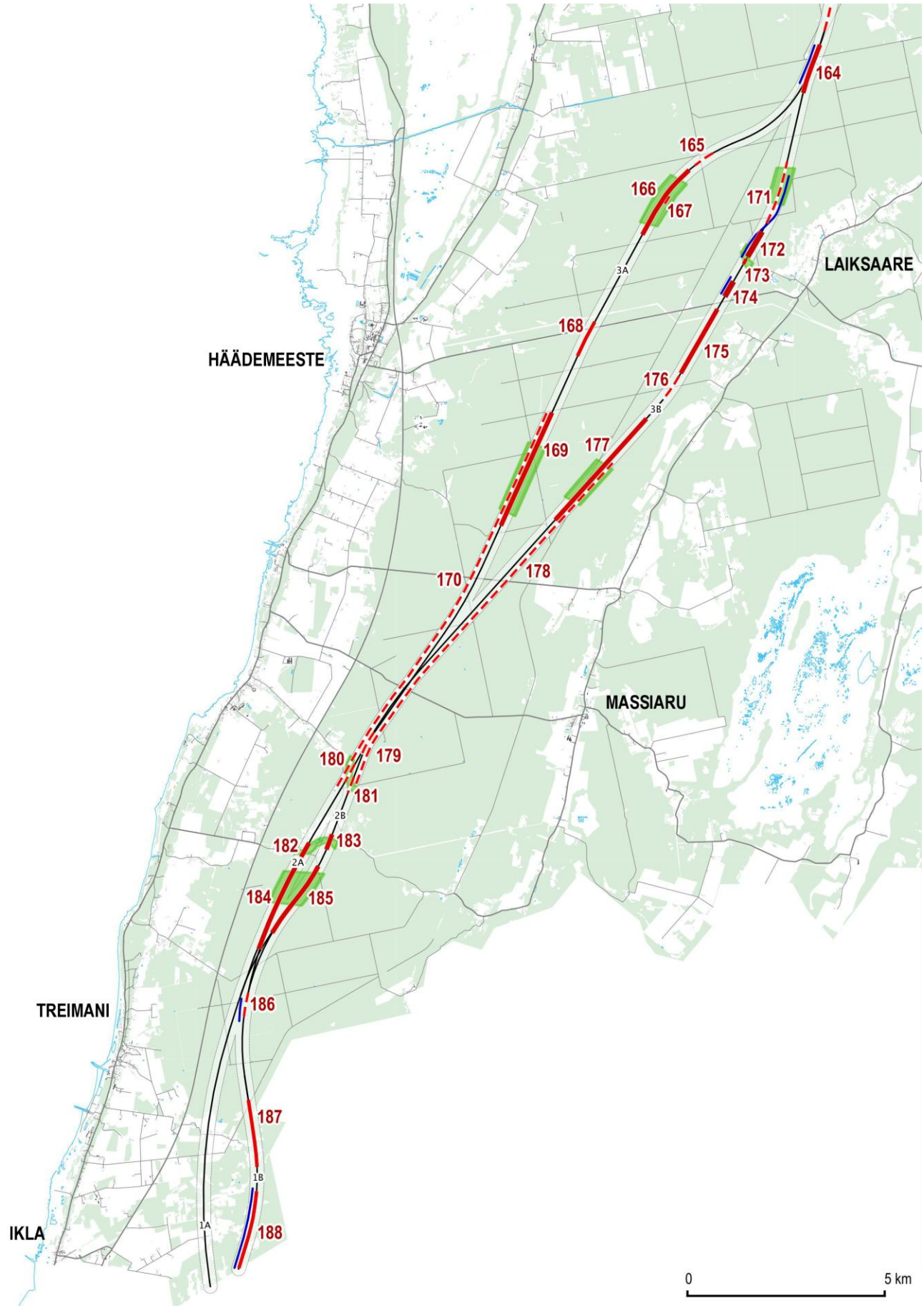


Table 6. Conflict sites depicted on the map 12 on the alternative railway lines. Relative scale of the rank: 1 – presumably weak effect of the railway that could be easy to compensate, 5 – strong and not compensatable effect.

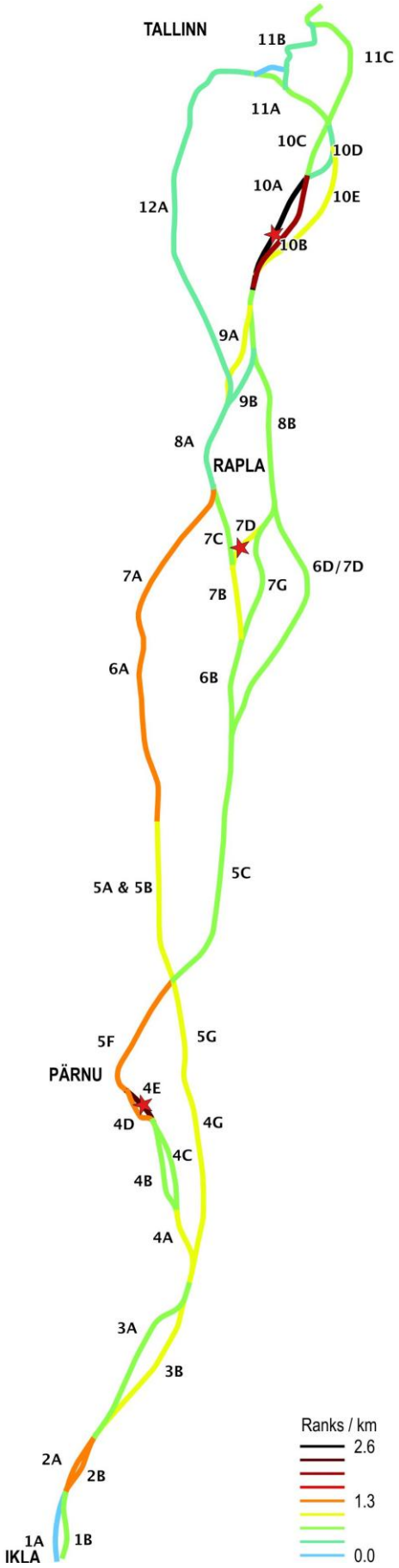
Site	Railway section	Predicted problem for railway construction	Rank	Suggested principle of solution	Mostly affected species / groups
164	3A/3B	Old-growth stand eastward from the line, and important bat feeding and nesting habitat related to the stream and old forest. Stream of salmons.	3	Keep to west and keep corridor as narrow as possible. Use a solution that retains open flight area on bats' flight altitude below or above the railway. Avoid artificial illumination. Avoid mudflow during railway construction.	Bats, salmons, old forest species
165	3A	Habitat of *Epipactis helleborine* (III cat. plant) around the line.	1	Keep corridor as narrow as possible, and retain water regime.	Plant
166	3A	Dispersal area of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
167	3A	Salmon stream.	1	Avoid mudflow during railway construction.	Aquatic animals and plants
168	3A	Habitat of II cat. protected bird eastward from the line, and old-growth pine stands.	2	Reduce noise, use lower fences to provide moving of the bird over the railway. Avoid construction activity during breeding season. Keep corridor as narrow as possible.	Bird, old forest species
169	3A	Dispersal area of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
170	2A, 3A	Bat feeding and nesting habitat in surrounding forests. High-quality habitat of protected bird (II cat.).	1	Retain forest habitats and streams, keep corridor as narrow as possible. Preserve water regime.	Bats, bird
171	3B	Dispersal area of large mammals. Nest of a I cat. protected bird westward from the line.	4	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it. Keep to east and avoid railway construction during nesting season.	Large and medium-sized mammals (incl. large carnivores), and bird
172	3B	High-value old-growth forest habitat on the line. Habitat of II cat. protected bird. Bat feeding and nesting habitat.	4	Select other alternative, if not possible, move railway corridor to west, and keep railway corridor as narrow as possible. Preserve old forest.	Forest birds, bats
173	3B	Natural salmon stream.	2	Provide bank path of semiaquatic animals. Avoid mudflow durin construction.	Semiaquatic animals, salmons
174	3B	High-value old swamp forest habitat, protected rock and plants, and habitat of protected bird (II cat.)	4	Select other alternative, if not possible, move railway corridor to west and keep railway corridor as narrow as possible. Retain water regime	Forest birds, plants
175	3B	High-value flood forest habitat.	3	Preserve water regime, or select the other alternative.	Plants
176	3B	Habitat of II cat. protected bird westward from the line.	1	Reduce noise, use lower fences to provide moving of the bird over the railway. Avoid construction activity during breeding season.	Bird
177		Dispersal area of large mammals.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals (incl. large carnivores)
178	2B, 3B	Bat feeding and nesting habitat in surrounding forests. High-quality habitat of protected bird (II cat.).	1	Retain forest habitats and streams, keep corridor as narrow as possible. Preserve water regime.	Bats, birds
179	2A, 2B	Pass between old forest stands	1	Keep railway corridor as narrow as possible and retain water regime.	Forest birds (incl. owls and raptors), old forest species
180	2A	Natural stream	1	Provide bank path for semiaquatic animals.	Semiaquatic animals
181	2B	Natural stream	1	Provide bank path for semiaquatic animals.	Semiaquatic animals
182	2A	Natural salmon stream.	3	Provide bank path for semiaquatic animals, avoid mud flow during construction.	Salmons, semiaquatic animals
183	2B	Natural salmon stream.	3	Provide bank path for semiaquatic animals, avoid mud flow during construction.	Salmons, semiaquatic animals
184	2A	Dispersal area of ungulates.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
185	2B	Dispersal area of ungulates.	3	Build wide ecoduct or other passthrough, and infrastructure that guides animals to it.	Large and medium-sized mammals
186	1B	Habitat of *Epipactis helleborine* (III cat. plant) on the line.	1	Keep corridor as narrow as possible and retain water regime. Keep to west.	Plant
187	1B	Several protected plants (III cat.), and high-value forest habitat on line.	2	Keep railway corridor as narrow as possible, and retain water regime.	Plant
188	1B	Important bat feeding and nesting habitat eastward from the line.	2	Keep to west, and preserve forest habitat.	Bats

Table 7. Comparision of the railway sections in respect of expected impact on biota. See detailed locations and descriptions of the conflict sites on maps 7–12 and in tables 1–6.

Code of railway section	**Section length,** km	**Number of conflict sites,** ranks 1-2-3-4-5 (total)	**Impact density,** ranks / km	**Total impact,** sum of effect ranks
1A	8	0-0-0-0-0 (0)	0,0	0
1B	8	1-2-0-0-0 (3)	0,6	5
2A	7	3-0-2-0-0 (5)	1,3	9
2B	7	3-0-2-0-0 (5)	1,3	9
3A	21	4-1-3-0-0 (8)	0,7	15
3B	21	2-1-2-3-0 (8)	1,0	22
4A	8	1-1-0-1-0 (3)	0,9	7
4B	10	0-1-2-0-0 (3)	0,8	8
4C	10	0-1-2-0-0 (3)	0,8	8
4D	5	0-0-1-1-0 (2)	1,4	7
4E ★	4	0-0-0-1-1 (2)	2,3	9
4G & 5G	35	1-3-8-2-0 (14)	1,1	39
5A	18	1-2-2-2-0 (7)	1,1	19
5B	18	0-1-3-2-0 (6)	1,1	19
5C	31	2-1-4-1-0 (8)	0,6	20
5F	15	1-3-1-2-0 (7)	1,2	18
6A & 7A	41	4-4-9-4-0 (21)	1,3	55
6B	11	0-1-2-0-0 (3)	0,7	8
6D/7D	30	1-3-4-1-0 (9)	0,8	23
7B	9	1-0-1-1-0 (3)	0,9	8
7C	9	0-0-2-0-0 (2)	0,7	6
7D ★	8	0-1-0-0-1 (2)	0,9	7
7G	15	0-1-1-1-0 (3)	0,6	9
8A	11	1-1-1-0-0 (3)	0,5	6
8B	18	1-2-2-0-0 (5)	0,6	11
9A	15	2-1-2-1-0 (6)	0,9	14
9B	16	1-0-1-1-0 (3)	0,5	8
10A ★	14	0-2-4-4-1 (11)	2,6	37
10B	14	0-2-3-3-0 (8)	1,8	25
10C	7	1-0-1-0-0 (2)	0,6	4
10D	5	0-1-0-0-0 (1)	0,4	2
10D/10E	3	1-0-0-0-0 (1)	0,3	1
10E	18	1-0-3-2-0 (6)	1,0	18
11C	18	2-3-1-0-0 (6)	0,6	11
11B	13	1-0-2-0-0 (3)	0,5	7
11A	11	0-2-1-0-0 (3)	0,6	7
12A	45	4-5-3-1-0 (13)	0,6	25

★ there is a conflict site of the highest rank on the railway section, and that section should be avoided. Conflict sites 28, 102 and 136 in tables 1, 3 and 5 respectively.

Figure 4. Impact density of the railway sections. The red stars denote three conflict sites of the highest rank that should be avoided.



CONCLUSION

To estimate the effect of the planned Rail Baltic railway on Estonian biota, we carried out an ecological survey that comprised synthesis of databases, field inventory and spatial modelling of natural habitats. Because of limited time of the survey, it has to be considered that all possible effects of the planned railway on Estonian flora and fauna could not be discovered. Despite of that, the analysis showed that the most extensive conflict is related to dispersal of various animals, and habitats of strictly protected species at local scale. The railway sections where potentially strong conflicts appeared should be avoided. Three major conflicting regions apeared: (1) Tuhala-Tammiku and surrounding areas in South Harjumaa that is mostly related to highly valuable habitats of various species – animals and plants, and socio-ecological attitude of society; (2) South Raplamaa that is related to large scale dispersal of animals, incl. ungulates and large carnivores; (3) forest and bog landscapes in surroundings of Pärnu and southwards, that is related to high-quality habitats of mammals and birds.

In general, we point out four principal recommendations of compensating measures that deserves attention all along the line: (a) to minimize effects on local flora and wildlife habitats, soil water regime should be preserved around the railway, but an extra attention is essential in the vicinity of natural wetlands (swamps and bogs); (b) the railway corridor has to be passable for small and medium-sized animals all along the way; (c) as large animals pose a threat to the rail traffic, it is reasonable to fence the Rail Baltic corridor, which in turn causes population fragmentation. To guarantee adequate connectivity of the populations, the large mammal passages have to be approximately every 10 km; (d) it is important to continue nature monitoring after the railway construction and implement additional compensating measures where necessary.

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