European Co-operation in the Field of Scientific and Technical Research

COST 341

The effect of linear infrastructures on habitat fragmentation

Hungarian State of the Art Report

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Chapter 1. Introduction

Local infrastructures of the late nineteenth century were self-supporting systems, operating on the regional level, such as a county or an industrial region. These systems were connected with the developmental centres of the wider environment and with the infrastructure systems beyond the surrounding borders. Mezo- and microregions of forested mountains and drained wetlands had been excluded from this infrastructure development. Due to their isolation, these areas became peripheries in terms of economic geography, but at the same time, shelters of biodiversity.

The flora and the fauna of a region and the change of the diversity of species were highly determined by the expanding urbanisation and the extension of the related infrastructural elements. Direct and indirect impacts of these improvements all decreased the area of natural and semi-natural environment.

After the political transition of 1989, infrastructure systems underwent a rapid development. Chiefly the market conform improvements, such as the telephone network, gas supply, landfills and the road system developed. Attention of experts observing the effect of investments and also that of politicians focused on the transformation of human environment (air- and noise-pollution, road safety). In spite of the alerts of nature conservation experts, hardly any studies were done on the effect of the altered environment on plant and animal communities and on their survival conditions.

On the occasion of nominating 1995 the “Year of European Nature Conservation” a conference was held in The Netherlands, in September 1995. The fragmentation of habitats by linear infrastructures was the main topic of the conference.

Linear infrastructures destroy “biologically active” surfaces and hinder the migration of species. The remaining habitat patches of limited extension may be too small for supporting the survival of some species. These phenomena all result in the decline of biodiversity.

The establishment of EECONET (European Ecological Network) was initiated by the Member States of European Community with the aim of establising a network of valuable habitats. Hungary joined the planning of the network in 1993 and the network was designed for the country.

The need of a new European programme Infra Eco Network (IENE) was expressed by the organisers of the conference in ‘95. The programme aims to study the effect of infrastructure development on habitat fragmentation at a European level.

Objectives of the IENE programme

- stimulation of co-operation and the exchange of expertise,
- European integration of the conservation of natural values,
- elaboration of an action plan on European level,
- set the priorities for the solution of conflicts between nature conservation and infrastructure development,
- compilation of a European manual for mitigation measures.

An EU supported scientific forum the COST (European COoperation in the Field of Scientific and Technical Research) provides the framework for the co-operative work. Hungary joined the COST in 1991.

COST is a multilateral European research-and-development cooperation forum in the field of scientific and technical researches and provides the opportunity of mutually beneficial integration of research programmes covering similar problems in different countries.

The present international project, initiated by the IENE, dealing with the fragmentation effects of infrastructure networks, was launched in September 1998. The first countries to join were Hungary, The Netherlands, Romania, Spain, Sweden and Switzerland.

GENERAL INFORMATION ABOUT COST 341

Objectives

The main objective is to promote a safe and sustainable pan-European transport infrastructure through recommending mitigation measures and planning procedures with the aim of conserving biodiversity and reducing accidents and animal road kills.

Duration of the project

4.5 years between September 1998 and July 2003

Deliverables

COST 341 project aims to demonstrate the current situation of habitat fragmentation caused by construction and use of the transportation networks in Europe, to gather the best practice regarding methodologies, indicators, technical design and procedures for avoidance, mitigation and compensation of adverse effects on nature in a handbook of best practice, to bring together information on European expertise. To set up a database on existing literature and a glossary of terms used in the field of infrastructure and habitat fragmentation in on-line database is also an important part of the project. Therefore, there are three main products to be delivered by COST 341: European State of Art Report, European Handbook and On-line Database.

The present volume is the National Report of Hungary to the COST 341 project which summarises the status of habitat fragmentation in Hungary caused by linear infrastructures on the base of researches regarding this topic.

Chapter 2. Ecological concepts

2.1. Introduction

The most fundamental, essential feature of the biosphere is diversity. Diversity is the basis for adaptation to the ever-changing conditions of life. **Biodiversity** is an independent qualitative category that cannot be compared or treated in relative terms. It is important in itself and for itself. The concept of biodiversity includes the different levels of diversity, from the genetic level, as a basis for all evolutionary and selection processes, to the level of species or even habitats. So, even biodiversity is diverse and all parts of it are important.

The function of self-organising systems of nature suffers serious damage due to human activities. These all can lead to a rapid degradation and a decrease of amenity value. In the long run, the accelerating decline of the self-sustaining ability of nature can lead to the transformation of the system.

The determination of the smallest viable population is a fundamental issue. What is the smallest number (so-called extinction threshold) of individuals needed for survival? The answer is usually not known. According to our recent knowledge, in case of herbal plants a population of 10.000 individuals can bear the genetic variability that is able to cope with stochastic environmental changes, and can keep the population alive in the long run. This is one of the reasons why the in situ conservation, as well as the control and the final blocking of fragmentation is essential.

Populations of species almost in all cases occur together with other species and this co-occurrence (so-called co-existence) is far from stochastic. The generally accepted principle of Gauze states that populations with the same ecological requirements and tolerance character, due to the competition, cannot live together in the long run. Species with a wide range of tolerance usually occur in several different communities. Appearance of weeds, for example, follows human activity that alters competitive interactions. The invasive plants are usually stress-tolerant, aggressive competitors. Due to their architecture, growth-form and strategy of dispersal they can modify the structure and dominance order of stable communities.

The regulation of ecological systems can be tracked from the level of populations up to the level of the biosphere. This regulation ensures diversity that is manifested at all levels of living systems and supports the extremely high variability of living organisms.

Human being has a special, leading role in this system. The human being is the only species that is able to hinder, control, eliminate and destroy other life forms around him. No other comparable organism known from the billiard-year history of the biosphere. This fact also suggests that human strategy is probably not a long-term adaptive strategy in terms of evolution.

2.2 Ecological networks

Natural and semi-natural areas and habitats should not be considered as strictly divided islands or “reserves”, but as unified and connecting systems. An ecological network is a coherent, functioning system, in which communication is active between natural habitats. Patches of habitats – with greater than a critical size – are the core areas. Their size is ideal in case they provide habitat and genetic reserve for the most possible populations among the given conditions. Communication between the core areas is realised by the so-called **ecological corri-**

dors. Ecological corridors are linear, continuous habitats, or habitat-chains with smaller or greater interruptions.

During the planning of the ecological network, the following main area-types were defined according to the system of the European Union Habitat Directive:

Core areas
Complex protection of biodiversity is a priority in these areas. The most suitable areas of protection are the natural and semi-natural habitats with a size beyond a critical threshold, which therefore can preserve high diversity of species. Potential of a long-term protection and stability of the site are fundamental viewpoints during the core area selection.

Buffer zones
To ensure the protection and stability of core areas, they have to be surrounded by buffer zones. These areas should be also semi-natural habitats, or even slightly degraded areas suitable for rehabilitation with adequate management.

Ecological corridors and stepping stones
(Stepping stones are habitat islands that enable the migration.)

The primary function of ecological corridors and stepping stones is:

- to provide connection between natural and semi-natural core areas,
- to ensure the natural migration and dispersal of species in a given region,
- to ensure the escape of species from the effect of unfavourable climate change,
- to support the gene-flow between the populations of a species living in different habitats.

2.3. Habitat fragmentation

Environmental influences penetrate into the heart of habitats. The neutralisation of these effects depends on the nature of the habitat. Furthermore, the size of the habitat and the parameters of the surrounding area are the main factors determining its stability in providing optimal conditions for populations. As a result, all habitats can be divided into an marginal-zone and a core area enclosed by the marginal-zone. Only the core area can provide long-term stability of optimal conditions for species. Even habitats exclusively under natural influences can be characterised by these zones. All roads and other linear infrastructure (electrical- and telephone cables, water- and gas-pipes, canals) create edge-effect in a habitat.

The size of the edges along a linear infrastructure is determined by the strength of the effect coming from the object and by the surrounding vegetation. In worst cases the total elimination of the habitat can take place, or if the core area is also affected, it may fall apart to smaller areas being no longer able to function as a core area. For example the flora and fauna of road edges are constantly impoverished by the traffic and by the road itself and consequently the core areas are damaged as well. Roads and their traffic can lead to the total isolation of populations: these objects are impenetrable barriers, especially for those species that can move just within their original habitat.

Species character change can be a result of limited gene-flow between its populations. Linear infrastructures, such as forest clearings can separate or eliminate core areas by increasing the edge-effect. Isolation of core areas can lead to the cessation of the gene-flow. Barriers that cut ecological corridors have primary importance. Corridors provide – continuously, or in habitat island systems (stepping stones) – conditions for dispersal, reproduction and migration of species (see Figure 2.1.). Spatial and temporal dimensions of these movements follow an individual pattern in case of each species. It can be limited, for example, only to the period of breeding or foraging. The success of these movements is guaranteed only if the species can transit through the barriers between the habitats. (While birds and flying insects can migrate long distances, smaller animals with limited ability of dispersal "migrate" just few metres per year. Plants show similar pattern: the distance of dispersal of small and wind-transported seeds is much greater than that of the large seeds. Great and heavy propagules can perform quick dispersal in case of carriage by birds or by water, but generally these seeds have less "effective" – for example ants – or no transporter. The dispersal of these plants is extremely slow.)

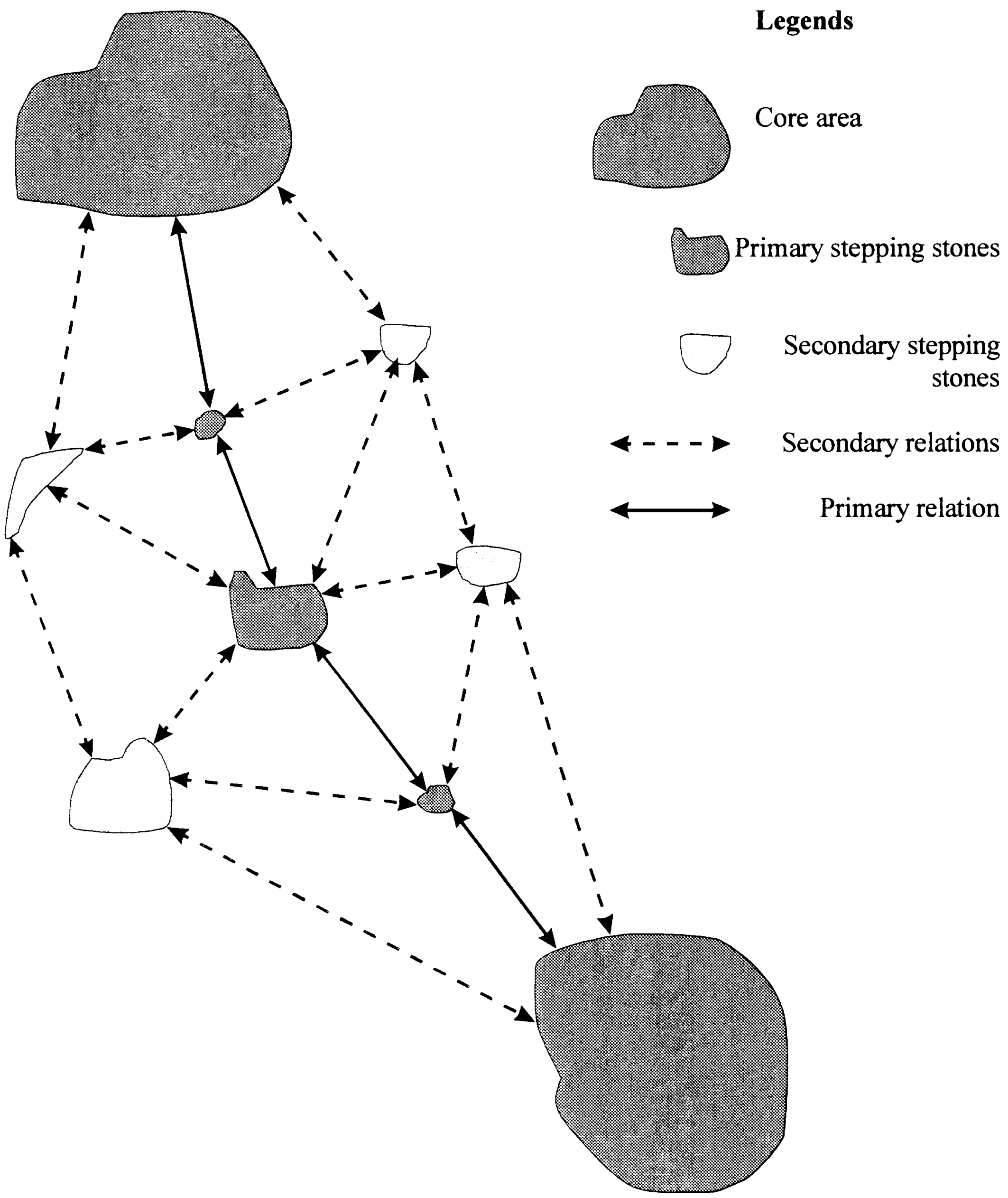


Figure 2.1. Scheme of ecological corridors

Habitat fragmentation is the division of habitats or habitat mosaics by territory loss. It is not identical with the natural isolation of some communities, generally of small area, such as fens or rocky grasslands. 'Dispersion' is a probably better, but still not completely accurate term in this case.

The conceptual interpretation of fragmentation is not coherent. Even professional papers confuse the two, following situations:

- three patches of oak forest with the size of 10, 100, and 1000 ha is controlled by an abiotic background variable,
- due to the effect of roads and other linear infrastructures, out of the original 3000 ha oak forest three patches remained with the size of 10, 100, and 1000 ha.

In the first case, species are adapted to the situation at an evolutionary time-scale, while they should adapt within few decades in the second case. In the first case, ecological corridors are not needed, hence originally separated habitats should not be linked. In the second case, the distances between patches cause total isolation for several species, ecological corridors have to be installed.

2.4. Summary

Some of those principles of ecology were described above which may deserve attention in choosing the route and designing roads. Under the existing technological potential a road can be constructed practically anywhere. This possibility frequently induces designers and decision makers to suppose that after resolving the technical problems nature can also be "subdued". Rare and protected plants are in most cases unsuccessfully transplanted if their habitat conflicts with the route design. To wait for animals to become accustomed to environmental constraints caused by investments is hopeless, they rather escape or die out. At the same time some other common stress tolerating plant and animal species become tolerant abundant. If we want to preserve biodiversity we have to acknowledge ecological principles and rules. By designing and realising ecological networks and other mitigating measures the adverse effects of infrastructure can be decreased significantly.

However, details for these measures (for example type of mitigation, minimum size of habitat) can only be given on the basis of thorough knowledge of nature.

Chapter 3. Effects of infrastructure on nature

3.1. Direct effects

Since data are only available for the effects of traffic, especially road traffic, hereafter under the term infrastructural effects, the effects of road traffic will be meant, unless otherwise stated.

The infrastructure of transport and especially the improvement of the road system can have a highly adverse effect on biodiversity. The harmful effect of operating factors only manifest in the long run. At the beginning of the process, the direct cumulative or synergetic effects are hardly recognisable. Only later they do become evident, when their handling gets much more complicated, or the detrimental processes have become irreversible.

3.1.1. Habitat loss and transformation

Habitat loss is one of the most striking effects. It is partly caused by roads themselves, partly by other linking establishments (petrol stations, rest areas, etc.) along the roads. A road leading across a natural countryside can have a spectacular "environment destroying" impression, but the auxiliary effect of additional roads in an already fragmented landscape is less striking.

Roadside verges are of outstanding importance. Their optimal width is obviously species dependent (20–500 metres) and gives a different value for the red deer or the beech. Semi-natural edge habitats often enrich the local flora and fauna enabling the emergence of new species. (Some plants and small animals – often rare and protected species – definitely rely on such edges.) However, the creation of edges and the resulting enrichment caused by linear infrastructures is often disadvantageous, because the road decreases the area of the intact inner parts of stands. The roads often affect the habitats of the most endangered species in the inner parts of stands. (*Asplenium fontaneum* became extinct from its only habitat in Hungary this way. This rock-dwelling fern fell victim to road constructions in the Fáni Valley.) Furthermore, the majority of new plant species gaining a foothold along linear infrastructures are ruderal or disturbance tolerant. Roadside verges act as ecological corridors for their propagation.

3.1.2. Disturbance (local pollution, fluctuations of water balance)

Effects of building up

Owing to building up, soil loses its original state and several of its features change (e.g.: moisture content) and becomes deprived of its properties favourable for plants. The parameters of the filter layer change (ground water becomes polluted more easily) and new land formations are created altering natural run-off conditions.

The load along roads leads to the compaction of soils. As a result, the volume of pores decreases (especially that of large pores) causing the decline of aeration and the change of heat-balance. The mobility of soil fauna also decreases, microbe activity and nutrient-balance change and the water permeability of soil decreases.

Effects of drainage and waterlogging

Drain canals built along roads together with run-off from roads permanently alter the water balance of soils. The area of the affected region greatly depends on the relief and the orientation of drain canals. The change is twofold: due to run-off the moisture content of soil decreases in some localities, while it increases caused by the collection of water in other places. While on average 15% of the precipitation runs off the surface of areas not built up, the ratio can be as high as 60-80% in built-up areas.

During road constructions the impermeable soil layers may be penetrated, causing the lowering of the watertable, which principally affects the composition of plant communities. In extreme case this can lead to the increased ratio of drought tolerant species and thus the replacement of the original vegetation. All these changes substantially influence the composition of the fauna (e.g.: the presence of pollinators) as well.

Effects of pollution originating from transport

Various substances are emited to the air with traffic. A portion of these quickly deposits onto roads and the surrounding ground. Pollution along roads is the highest within the first few metres and becomes relatively low at a distance of 20 metres, although a measurable amount of whirled dust can get as far as 1000 metres from the road. The amount and spread of dust basically depends on the soil type, vegetation, relief, the speed of vehicles, exposure and moisture conditions. Large amount of dust can deposit on the vegetation along roads.

Acid load

One of the most important impacts of transport – and therefore roads – on the environment is that of various acids (Nunné 1994). Among them nitric acid and nitrous acid are the most fundamental, which deposit to the ground surface from various nitrogen-oxides (NO_X) from the atmosphere. Owing to acidification, the species composition of soil microorganisms changes – e.g.: the ratio of fungi increases at the expense of bacteria – and some organisms disappear. It is partly soil acidification – and therefore transport – that causes the phenomenon called “new type of woodland deterioration” which affects most woodlands in Europe.

Effects of salts

Deicing salts are applied to the majority of our roads in winter to ensure a steady traffic. The amount of salt spread this way can be considerable (0.8–1.2 kg/m^2 by public road maintenance and handling rules). Consequently, a great amount of $NaCl$ or $MgCl_2$ can get into the soil. The increased amount of Na in the soil replaces Ca and Mg on the surface of the adsorption complex. Sodium ions have large hydrate coatings, which can cause the peptisation of soil and the loss of drainage, which ultimately increases the hazard of erosion.

Salt accumulation along roads can have a drastic impact on the quality of vegetation. The decay of town tree species (e.g.: horse-chestnut, plane) along the roads of Budapest is a common phenomenon. The impact is partly direct, partly indirect: weakened specimens are attacked by parasites. The adverse effects of salting can be apparent in the case of natural vegetation as well, although not much is known about them.

3.1.3. Effects on animals

The influence of various types of roads on animals largely depends on the quality of road surface (earth, asphalt, concrete), its width and the temporal and spatial distribution of traffic intensity. These effects principally affect arthropods, amphibians, reptiles, birds, and mammals.

The degrading effects may be direct, e.g.: habitat segregation, road kills, pollution, modification of migration route or indirect, e.g.: disturbance, pollution, and their consequences. Feathered and furry animals are relatively easy to identify even several days after their death.

In the case of other taxa (especially arthropods, amphibians, reptiles) identification is difficult in the lack of identification marks. As a result, the number of run-over animals is usually significantly underestimated (Hels 1999) and the assessment of damage done to their populations is complicated if not impossible. The alteration of population structure, however, has a direct influence on the composition of a given community and the temporal and spatial changes of other plant and/or animal populations.

Chapter 4. National and European relationships, features

4.1. Biogeographic description

4.1.1. Land-use history in the Carpathian Basin

Man has been present in Eurasia for hundreds of thousands of years. At the beginning, the main source of living was hunting and gathering which did not have a significant effect on the natural environment. During the late Ice Age, the Palaeolithic, about 4000 people, in the Mesolithic about 16–17,000 people must have inhabited the 325,500 km^2 area of the Carpathian Basin. The warming of the climate contributed to the population growth.

Substantial land-use – animal husbandry and agriculture – must have begun in the Neolithic, approximately the second half of the sixth millennium BC. This was the so-called Atlantic era in vegetation history, when the climatic steppes of the Great Hungarian Plain became forested, mainly with oak. This process is likely to have been influenced by human deforestation and farming. In the second-third part of the Neolithic the first dwelling hillocks ("tell" in Hungarian) appeared indicating the gradual conversion of the landscape. As food production started, population boom resulted in the exploitation, transformation and destruction of the natural vegetation.

In the subboreal era of vegetation history the climate became slightly cooler causing the spread of beech. In the second half of the subboreal era, the rotation system of farming and shepherding became widespread, accompanied by substantial deforestation. Beside bronze making and metallurgy that started to spread from the second millennium BC, tumulus ("kurgán" or "kunhalom" in Hungarian), earthwork and mound building, pottery and cremation burials also required a lot of wood. Later, as the major part of the Great Hungarian Plain became inhabited, villages were also built in the closed oak zone of the mountain ranges. According to pollen analytical studies the ratio of the pollens of cereals and segetal weeds greatly increased from this time on. Based on these results, the first big wave of deforestation is assumed to have started in the Iron Age, second millennium BC. Owing to the fast development of farming tools huge areas were turned into arable fields.

At the beginning of our era, Romans arriving at the Carpathian Basin found and brought highly developed (mainly Celtic) agricultural technologies. The Empire also served as an immense market for the goods originating form here. Large farms became widespread at this time and partly survived even after the disintegration of the Province. Nomadic and other tribes (Alans, Sarmats, later Huns and Avars, finally Hungarians) that arrived at the Great Hungarian Plain at this time or later, found settled communities with long plant cultivation traditions. The immigrants, after settling down, dealt with animal husbandry and farming.

The early Middle Age was characterised by further deforestation. Beside house building, charcoal-burning and the firewood supply of the ever increasing population also required large amounts of wood. The last great deforestation of the Great Hungarian Plain, which resulted in a landscape similar to that of nowadays, must have taken place in the Turkish era. Owing to long lasting wars and the spread of animal grazing vast territories became treeless steppes. The subsequent extensive grazing could have maintained the steppes.

In the middle of the last century, demand for arable land increased thanks to cereal prosperity, so practically all loess steppes were tilled. (Fertile loess fields were ploughed and cultivated as early as the 11–12th century AD under the reign of the Árpád dynasty kings.) As a consequence of the canalisation of rivers and drainage in the 19th century, evaporation exceeded the amount of precipitation by far resulting in the crystallization of salt on the soil surface and the increase of the area of salt marshes. Later, as grazing became more intensive and fodder was grown in ever larger quantities, the fragmentation of grasslands was further enhanced.

The present labdscape of the Carpathian Basin was formed as a result of the processes briefly described above. The development of the actual vegetation has been affected by human activities since the Atlantic era. Therefore, the early and present role of man in the formation of the landscape should always be taken into consideration when designing and executing management, research and nature conservation works.

4.1.2. Description of the main biogeographical zones of Hungary

Hungary is situated mainly in the zone of European deciduous woodlands. The Great Hungarian Plain, however, belongs to another climatic vegetation zone, being the westernmost extension of the Eastern European mosaic of woodlands and steppes, the so-called forest steppe. The western boundary of the country – owing to alpine climatic effects – belongs to the region of Middle European mixed coniferous woodlands.

Natural vegetation is the original vegetation of a region, evolved without any human influence. Potential vegetation would develop in the absence of man from now on. Actual vegetation refers to the vegetation found presently. This, mainly secondary vegetation in most of the Carpathian Basin is only partly considered (mainly in the mountain ranges) semi-natural or natural.

The discussions below are based on the results of floristic and phytocoenological researches done primarily in Hungary. The potential vegetation of destroyed areas can be inferred from the bedrock, relief, local climate and the present semi-natural vegetation types. (This method was applied when creating the potential vegetation map of Hungary.) Outputs of the examinations of the actual vegetation may be applied to the natural vegetation, but only with care.

Great Hungarian Plain region

Its complete area, covered by Pleistocene and Holocene wind and river sediment, belongs to the forest steppe zone. Today it is mostly arable land with small patches of the remaining natural vegetation. Larger rivers are accompanied by enormous gallery forests, the areas between rivers are composed of the mosaic of sand dunes and loess and salt steppes. The last remnants of the once extensive marshes still exist locally with some remarkable glacial relict species.

Owing to its relative isolation – the Great Hungarian Plain is surrounded by medium and high mountains – the number of endemic plant species (and subspecies) is relatively high (about 20). Some of them have become rare due to human activities and there are plenty of threatened species living at the limit of their ecological requirements.

Some endemic species (most also threatened) are as follows: *Suaeda pannonica, Limonium gmelinii* subsp. *hungaricum, Dianthus serotinus* subsp. *serotinus, Festuca vaginata, Dianthus diutinus, Adonis x hybrida* syn.: *A. transsilvanica, Pulsatilla pratensis* subsp. *hungarica, Aster sedifolius, Sedum urvillei* subsp. *hillebrandtii, Epipactis bugacensis* and other *Epipactis* species, *Linum hirsutum* subsp. *glabrescens, Plantago schwarzenbergiana, Onosma arenaria* subsp. *tuberculata, Armoracia macrocarpa, Cirsium brachycephalum, Tragopogon floccosus, Colchicum arenarium*.

Figure 4.1.2.1. Alkaline steppe in the Hortobágy National Park.

Noteworthy species (most of them have a continental or Pontic-Pannonian area) are: *Crataegus nigra, Vitis vinifera subsp. sylvestris, Crambe tataria, Urtica kioviensis, Salvia nutans, Plantago maxima, Potentilla palustris* syn.: *Comarum palustre, Trollius europaeus, Bulbocodium vernum, Pulsatilla patens, Rumex pseudonatronatus, Astragalus exscapus, Astragalus dasyanthus*, etc.

Northern Mountain Range region

The foothill zone of the inner region of the Carpathian Mountains is made up of mainly volcanic rocks (especially andesite) and partly limestone. The warm southern slopes are covered by thermophilous Pannonic vegetation at lower elevations and dry oak (chiefly Turkey oak) woodlands over 600 m. Above this region oak-hornbeam woodlands, higher above colline beech woodlands are found. True montane beech woodlands are rare in Hungary only present over 900 m of elevation.

The number of endemic species – partly common with those of the Carpathian Mountains – is relatively high: *Cardamine glanduligera* syn.: *Dentaria glandulosa, Thlaspi kovatsii* subsp. *schudichii, Dianthus praecox* subsp. *lumnitzeri, Onosma tornensis, Minuartia hirsuta* subsp. *frutescens, Sesleria heufleriana* subsp. *hungarica, Ferula sadleriana, Poa pannonica* subsp. *scabra, Erysimum wittmannii* syn.: *E. pallidiflorum, Hesperis matronalis* subsp. *nivea* syn.: *H. m.* subsp. *vrabelyiana, Thlaspi jankae, Helleborus purpurascens, Pulsatilla pratensis* subsp. *zimmermannii, Carduus collinus*.

The number of protected and endangered species is very high, only some are listed here: *Lonicera nigra, Matteuccia struthiopteris, Aster oleifolius, Dracocephalum austriacum, Dracocephalum ruyschiana, Ribes alpinum, Allium victorialis, Clematis alpina, Micromeria thymifolia* syn.: *Calamintha th., Dryopteris cristata, Physospermum cornubiense* syn.: *Danaa cornubiensis, Viola biflora*, etc.

Figure 4.1.2.2. Pioneer rocky vegetation on the vulcanic rocks of the Mt. Füzér (Zemplén Mts, NE Hungary).

Transdanubian Mountain Range region

This block mountain is composed of sedimentary rocks (limestone, Triassic dolomite, sandstone) in the major part, and volcanic rocks in the minor part. It is characterised by a strong submeridional (Submediterranean with a dry summer) climatic effect. The surface weathering of sedimentary rocks favours the establishment of thermophilous and rock vegetation and the survival of glacial relicts on the northern slopes. Turkey oak – sessile oak woodlands are found on deep soils, while shallow soils are covered by closed thermophilous oak woodlands, scrublands and rock grasslands. Substantial beech woodlands are only found in the Bakony mountains or extrazonally, depending on the microclimate (in valleys, on northern slopes). Dolomite bedrock is of great importance for the flora, hosting several specialist and endemic species. The majority of glacial relicts is also found on the northern slopes of dolomite ravines.

The number of endemic species is relatively high (around 20), including plants that have only one or few populations in the world: *Linum dolomiticum, Pyrus magyarica, Vincetoxicum pannonicum, Sesleria sadleriana, Primula auricula* subsp. *hungarica, Knautia kitaibelii* subsp. *tomentella, Achillea × horanszkyi*.

Additional endemic and subendemic species are: *Seseli leucospermum, Dianthus serotinus* subsp. *regis-stephani,* many *Sorbus* minor species, *Draba lasiocarpa, Inula oculus-christi*, etc.

There are a lot of protected, endangered or relict species, e.g.: *Primula farinosa, Allium victorialis, Dryopteris cristata, Carduus crassifolius* subsp. *glaucus, Scabiosa canescens, Sternbergia colchiciflora, Doronicum hungaricum, Aethionema saxatile*, etc.

Figure 4.1.2.4. Forest-steppe vegetation, patches of calcareous grasslands and xerothermic oak woodlands on dolomitic rocks in the Bakony Mountains (Transdanubian Mountain Range).

Southern Transdanubian region

The climatic effect of the Balkans is getting stronger towards the south. There is a gradual transition towards the Illyrian (Western Balkan) flora domain and the Balkan character of the vegetation increases to the south of the Lake Balaton. The bedrock is composed of basic and acid sand, loess and sedimentary rocks (especially limestone, but also sandstone and dolomite). Lowlands and rolling areas that receive a lot of precipitation are covered by beech and oak-hornbeam woodlands; drier areas host pedunculate oak and Turkey oak – sessile oak woodlands. On the southern slopes of the Villányi and Mecsek mountains thermophilous Pannonic-Balkan grasslands and woodlands are found, beech and oak-hornbeam woodlands are only present on the northern slopes.

Endemic species are: *Colchicum hungaricum, Paeonia officinalis* subsp. *banatica, Festuca dalmatica* var. *pannonica, Vincetoxicum pannonicum.*

The number of species of southern character is outstandingly high (over 50), most are endangered, protected and subendemic with a Submediterranean or Pannonic-Balkan area: *Vicia oroboides, Teesdalia nudicaulis, Digitalis ferruginea, Lamium orvala, Cardamine trifolia* syn.: *Dentaria t., Lathyrus venetus, Anemone trifolia, Peucedanum verticillare, Inula spiraeifolia, Orchis simia, Ranunculus psilostachys, Orobanche ramosa* subsp. *nana*, *Trigonella gladiata, Doronicum orientale, Asperula taurina*, etc. Some extremely rare and remarkable species are also found in the fens of the region, e.g.: *Caldesia parnassifolia, Aldrovanda vesiculosa, Osmunda regalis*.

Figure 4.1.2.5. *Paeonia officinalis* subsp. *banatica* an endemic species of the Mecsek Mts (Southern Transdanubian region).

Western Transdanubian region

The climate is wet and cool because of the proximity of the Alps. The bedrock is principally acid metamorphic crystalline rock (schist) with some sand and clay and a minor amount of basic sedimentary rocks. Pannonic xerothermic vegetation is limited to small areas, the characteristic vegetation being rich in submontane and boreal elements. Scots pine woodlands mixed with oak, beech woodlands and oak-hornbeam woodlands reach large extensions.

Endemic species are more or less absent from this region (e.g.: *Daphne cneorum* subsp. *arbusculoides*). The rare alpine or montane elements found exclusively here in Hungary are much more significant, some of them being highly sensitive and endangered: *Goodyera repens, Chimaphila umbellata, Rhynchospora alba* (extinct), *Matteuccia struthiopteris, Vicia oroboides, Moneses uniflora, Tephroseris aurantiaca* syn.: *Senecio aurantiacus, Arnica montana, Crocus vernus* subsp. *albiflorus, Alnus viridis, Thlaspi goesingense, Thlaspi alpestre, Globularia cordifolia, Pinguicula vulgaris, Buphthalmum salicifolium, Gentiana asclepiadea*, etc.

Figure 4.1.2.6. *Gentiana asclepiadea* a rare species occurring in western Hungary.

4.2. POTENTIAL EFFECTS OF INFRASTRUCTURE ON THE BIOTA OF HUNGARY

Objectives, definitions and the explanation of evaluation categories

In this chapter the impact of roads and other linear infrastructures on the vegetation are assessed. Since no explicit research data are available, the following approaches were used for the assessment:

1. The characteristics of habitats were examined to estimate their susceptibility to fragmentation;

2. The intensity of the effects of fragmentation was evaluated for all possible influences.

The most characteristic and frequent habitats were studied among the natural, semi-natural and cultural habitats of the country (Tables 4.2.1. and 4.2.2.). The list of habitats was compiled on the basis of the General Hungarian Habitat Classification System (Á-NÉR, Fekete *et al.* 1997, see also for habitat codes in Tables 4.2.1. and 4.2.2.) and the Red Data Book (Borhidi & Sánta 1999).

Habitat characteristics

Typical stand size (diameter) – Correlates with the chance of a given habitat to be hit by roads. Potential values (in metres) are: 10, 100, 1000, over 1000 metres.

Frequency of natural disturbance – The frequency of natural disturbances (e.g.: flooding, grazing, erosion) can play an important role in the sensitivity of habitats to anthropogenic disturbances. Potential values are: several per year, once per year, several per decade.

Longevity of dominant species – The average maximal age of the dominant species. It indicates the time scale of the dynamics of the habitat. Potential values are: 1, 10, 100, over 100 years.

Table 4.2.1. Habitat characteristics and state of art of fragmentation in Hungary

Habitat characteristics	Submerged vegetation (A1–A5)	Reeds (B1–B3)	Sedges (B4–B5)	Salt marshes (B6)	Mires C1–C3)	Fens (D1–D2)	Tallgrass meadows (D3–D5)	Colline and mountane semi-dry grasslands (E1–E5)	Saline steppes (F1–F3)	Saline swards (F4–F5)	Open sandy grasslands (G1)	Rock grasslands (G2, G3, H1)	Slope steppes and secondary meadows (H3, H4)	Loess and sand steppes (H5)	Fen-woodlands (J1, J2)	Willow shrubs and forests (J3, J4)
Typical stand size (diameter in m)	10–100	100–1000	10–100	100	10–100	100–1000	10–1000	100–1000	Over 1000	10–100	100–1000	10–100	100	10–100	100	10–100
Frequency of natural disturbances	Once per year – several per decade	Once per year – once per decade	Once per year – once per decade	Once per year – once per decade	Once per decade	Several per decade	Once per year – once per decade	Once per decade	Once per year – once per decade	Once per year – several per decade	Once per year – once per decade	Once per year – once per decade	Once per decade	Once per decade	Once per year	Several per year
Longevity of dominant species	1–10	10–100	10–100	10–100	10–100	100	100	10–100	1–100	1–10	1–10	1–100	10–100	10–100	100 – over 100	1–100
Susceptibility to edge effect	medium	high	little	little	high	high	high	medium	little	little	little	little	medium	medium	high	medium
Resilience	high	high	little – medium	high	little	medium	medium	medium	high	high	high	high	little	little	medium	high
Geographical distribution	wider	wider	wider	Pannonic–Balkan–Pontic	wider	wider	Pannonic–Balkan–Pontic, wider	wider	(sub)endemic Pannonic–Balkan–Pontic	(sub)endemic	(sub)endemic	Pannonic–Balkan–Pontic	Pannonic–Balkan–Pontic	Pannonic–Balkan–Pontic	wider	wider

State of the art of fragmentation in Hungary (Table 4.2.1. continued)

Habitat characteristics	Submerged vegetation (A1–A5)	Reeds (B1–B3)	Sedges (B4–B5)	Salt marshes (B6)	Mires C1–C3)	Fens (D1–D2)	Tallgrass meadows (D3–D5)	Colline and mountane semi-dry grasslands (E1–E5)	Saline steppes (F1–F3)	Saline swards (F4–F5)	Open sandy grasslands (G1)	Rock grasslands (G2, G3, H1)	Slope steppes and secondary meadows (H3, H4)	Loess and sand steppes (H5)	Fen-woodlands (J1, J2)	Willow shrubs and forests (J3, J4)
Distribution in Hungary	•••	•••	••	•	•	••	••	••	•••	•	•••		•	••	•	••
Degree of habitat loss	•••	••	•••	••	•	•••	•••	•	•	•	••	••	•	••	••	••
Degree of fragmentation	•	•	•	•	•	••	•••	••	••	•	•••	•	••	••	••	••
Success of invadors along corridors	••	•••	•	•	•	•••	••	••	•	•	•••	•	••	•	••	•••
Role of corridors in the secondary formation of habitats	••	•••	•	•	•	•	•	•	•	•	••	•	•••	•••	•	•
Possibility of pollution	•••	•••	•••	•	•••	••	•••	•	•	•	•	••	•	•	•••	•••
Possibility of hidrological change	•••	•••	•••	•••	•••	•••	•••	•	••	••	•	•	•	•	•••	•••
Enhancement of erosion	•	•	•	•	•	•	•	•••	•••	•	•	•	••	••	•	•
Susceptibility of habitats to fragmentation	•	••	••	•	••	•••	•••	•	••	•	••	•	•	••	••	•••

Table 4.2.2. Habitat characteristics and state of art of fragmentation in Hungary

Habitat characteristics	Riverine oak-elm-ash and riverine ash-alder woodlands (J5, J6)	Pannonic oak-hornbeam woodlands (K2)	Pannonic neutral colline and montane beech woodlands (K5)	Western and Illyrian beech and oak-hornbeam woodlands (K3, K4)	Ravine, slope and acid woodlands, and woodlands on rocks (K6, K7, L3, L4)	Closed termophilous oak woodlands and turkey oak-sessile oak woodlands (L1, L2)	White oak shrub woodlands (M1)	Steppe oak woodlands (M2-M4)	Poplar-juniper steppe woodlands (M5)	Acid Scots pine woodlands (N1)	Secondary and degraded grasslands on the Great Hungarian Plain (O5, O6, O11, O12)	Secondary and degraded colline and montane grasslands (O5, O6, O11, O12)	Grasslands with spontaneously colonising trees and shrubs (P2)	Black locust and hybrid poplar plantations (S1, S2)	Black and Scots pine plantation (S4)
Typical stand size (diameter in m)	100–1000	Over 1000	Over 1000	Over 1000	10–100	Over 1000	100–1000	10–1000	100–1000	100–1000, over 1000	100–1000, over 1000	100–1000, over 1000	10–1000	100–1000, over 1000	100–1000, over 1000
Frequency of natural disturbances	Once per year – once per decade	Several per decade	Several per decade	Several per decade	Once per year – once per decade	Several per decade	Once per year – once per decade	Once per decade	Once per year – once per decade	Several per decade	Several per year – decades	Several per year – decades	Once per year – once per decade	Once per year – once per decade	Once per year – once per decade
Longevity of dominant species	100, over 100	100, over 100	Over 100	Over 100	100, over 100	100, over 100	100, over 100	100, over 100	10–100	100, over 100	1–100	1–100	10–100	10	10
Susceptibility to edge effect	high	medium	medium	medium	medium	medium	little	medium	little	medium	little – high	little – high	little	little	little
Resilience	little	medium	high	high	high	medium	medium	little	high	medium	high – medium	medium	high	little	little
Geographical distribution	wider	wider	wider	wider	(Sub)endemic – Pannonic–Balkan–Pontic	Pannonic–Balkan–Pontic	Pannonic–Balkan–Pontic	Pannonic–Balkan–Pontic	(sub)endemic	wider	wider	wider	wider	wider	wider

State of the art of fragmentation in Hungary (Table 4.2.2. continued)

Habitat characteristics	Riverine oak-elm-ash and riverine ash-alder woodlands (J5, J6)	Pannonic oak-hornbeam woodlands (K2)	Pannonic neutral colline and montane beech woodlands (K5)	Western and Illyrian beech and oak-hornbeam woodlands (K3, K4)	Ravine, slope and acid woodlands, and woodlands on rocks (K6, K7, L3, L4)	Closed termophilous oak woodlands and turkey oak-sessile oak woodlands (L1, L2)	White oak shrub woodlands (M1)	Steppe oak woodlands (M2-M4)	Poplar-juniper steppe woodlands (M5)	Acid Scots pine woodlands (N1)	Secondary and degraded grasslands on the Great Hungarian Plain (O5, O6, O11, O12)	Secondary and degraded colline and montane grasslands (O5, O6, O11, O12)	Grasslands with spontaneously colonising trees and shrubs (P2)	Black locust and hybrid poplar plantations (S1, S2)	Black and Scots pine plantation (S4)
Distribution in Hungary	•	•••	••	••	•	•••	•	•	••	••	•••	•••	•••	•••	•••
Degree of habitat loss	•	•	•	••	•	••	•	•	••	•	•••	•••	••	•	•
Degree of fragmentation	••	••	•	••	•	•••	•	•	••	••	•••	•••	••	•	•
Success of invadors along corridors	••	•	•	•	•	••	••	•	•	•	•••	••	•	•••	•••
Role of corridors in the secondary formation of habitats	•	•	•	•	•	•	•	•	•	•	•••	•••	••	•	•
Possibility of pollution	•••	•	•	•	•	•	•	•	•	•	••	•	•	•	•
Possibility of hidrological change	•••	••	••	•	•	•–••	•	•	•	••	••	••	•	•	•
Enhancement of erosion	•	••	••	•	••	••	••	•	•	•	•	••–•••	••	•	•
Susceptibility of habitats to fragmentation	••	•	•	••	•	••	•	•	•	•	••	••	••	•	•

Susceptibility to edge effect – The changes taking place in the margin of a habitat when crossed by a road. Potential values are: little, medium, high.

Resilience – The ability of a given habitat to return to or near its original state, following a major disturbance. Potential values are: little, medium, high.

Geographical distribution – The global distribution of a habitat appraised at three scales. Potential values are: (sub)endemic, Pannonic–Balkan–Pontic, wider.

Distribution in Hungary – An estimated value due to lack of exact data. Potential values are: rare, sporadic, frequent.

External influences on habitats

Degree of habitat loss – Deterioration caused by roads was assessed. Potential values are: small, medium, high.

Degree of fragmentation – The extent of fragmentation caused by the present road system. Potential values are: small, medium, high.

Success of invaders along corridors – An estimation based on field experience of the chance of alien invader species to move along roads leading across a given habitat and to enter the stands of the habitats. Potential values are: little, medium, great.

Role of corridors in the secondary formation of habitats – The ability of a habitat to appear secondarily along roads. Potential values are: small, medium, great.

Potential of pollution – The extent of pollution intrusion into the habitats. Potential values are: little, medium, great.

Possibility of hydrological change – The influence of roads on the hydrological condition of the affected stands. Potential values are: little, medium, great.

Enhancement of erosion – The influence of roads on erosion. Potential values are: little, medium, great.

Synthesized index of habitat susceptibility

Susceptibility of habitats to fragmentation – A combined measure of the above features. Potential values are: little, medium, high. It is worth noting that little or high susceptibility can be the result of several combinations and therefore, it does not substitute for the above database.

Effects of the road network on animals

Arthropods

Arthropods of different life cycles are susceptible to the influence of traffic to various extents (Mader *et al*. 1990). Traffic can cause considerable damage to insect populations that fly in a short period of time in great numbers over roads. Such are, primarily during swarm, some bees (e.g.: *Apis mellifera*), some beetles: the protected stag beetle *Lucanus cervus* or aquatic beetles: the protected great black water beetle *Hydrous piceus*, or members of the water beetle (Dytiscidae) family. Several nocturnal and diurnal butterflies are also threatened. Diurnal species are much more endangered by traffic than nocturnal ones (water scavenger beetles, water beetles, aquatic bugs). As opposed to swarming behaviour (limited only to a short period of the year), arthropods whose feeding and dwelling habitats are divided by roads, are restricted or ravaged by traffic during nearly the whole vegetation period. Similarly, aquatic beetles are also in danger, owing to nocturnal dispersion swarm characteristics. As they cannot differentiate between water surface and the similarly glittering wet road surface, they might land on the roads and fly away with difficulty. This way enormous numbers can be killed by traffic.

Carnivorous or necrophagous protected carabids may also fall victim to road traffic, as they feed on the carcass of previously run-over animals lying on roads (Eversham & Telfer 1994). Distinction must be made between good flyers (hymenopterans, dragonflies) and poor, slow, straight flyers (beetles, butterflies), the latter group being much more vulnerable. Beside the direct impacts, bare road surfaces stretching long distances can cause the fragmentation of populations too. Studies have shown that road-like objects deter some insect species [ladybirds (Coccinellidae) (Sárospataki & Markó1995), hover-flies (Syrphidae) (Lővei *et al.* 1998)] from trying to fly over. This phenomenon is caused by the ecophysiological properties of roads completely different from the habit and microclimate of the surrounding environment. As a result, gene-flow among the subpopulations becomes highly restricted or even ceased, which may cause their genetic impoverishment and finally extinction. The majority of wild bee species use various habitat fragments (hive habitat, feeding habitat, nesting material collecting habitat), which, if separated by roads can cause the decline of the given Hymenoptera population (Matheson 1996).

Amphibians

The group of animals belonging to the most threatened organisms as regards both abundance and species number is the class of amphibians (Bakó 1999; Hels 1999). Several works prove that road traffic drastically decreases the abundance of amphibian populations (Puky *et al.* 1990; Hels 1990). The reason is that most amphibians have different habitats for mating, overwintering and feeding (Marián 1987). Fire salamanders, newts and frogs, waking up from hibernation in spring start migrating to small or large ponds to mate and lay their eggs. Should

Figure 4.2.1. Slow-moving migrating species like the common toad (*Bufo bufo*) are especially endangered.

this migration route be crossed by a road, as much as 70–90% of the population may be destroyed under car wheels. The influence of roads on amphibians is species specific. The number of perishing individuals basically depends on the daily activity and migration speed of the given species compared to the density of vehicles and the width of road surface (Hels 1999). The daily distribution of traffic is equally important. At roads where traffic is evenly distributed in time, the daily activity pattern is less important. Such roads are motorways and other heavy traffic roads (e.g.: highways leading to the frontier). The migration speed of species has a more prominent role in the survival of a given individual in these cases, than does the intensity of traffic (Hels 1999). Another complicating factor is that the majority of frog species [e.g. toads (Bufonidae)] were found to behave in a different way on road surfaces, than on natural ground in the herb layer. Roads, having a higher temperature than the surroundings, coupled with better sight conditions, make frogs pause and linger on the roads for long (Puky *et al.* 1990). Being cold-blooded animals, frogs are very keen on staying on the warm surface of roads and furthermore males are more likely to catch sight of females approaching ponds. At a certain level of traffic intensity the number of adult amphibians drops so drastically, that the number of eggs laid will be lower than if eaten by predators. Consequently – although some specimens manage to survive the slaughter of traffic and even reproduce – the survival of the population becomes uncertain (Hels 1999).

Not all amphibian species are threatened equally in Hungary. Vulnerability depends on the migration features, avoiding strategy, and population size of the species. Slow-moving animals that migrate in concentrated, large masses are most prone to danger. Such species are the common and green toad (*Bufo bufo*, *Bufo viridis*), the spadefoot toad (*Pelobates fuscus*), to a lesser extent the fire salamander (*Salamandra salamandra*), the crested newt (*Triturus cristatus*), the European treefrog (*Hyla arborea*), the agile frog (*Rana dalmatina*) and the common frog (*Rana temporaria*) living in the Northern Mountain Range. Amphibian larvae become small frogs in July and August and leave the water to migrate to their feeding and overwintering habitats. Although this migration is less intense than in spring, the number of animals can be many times more than that of adults migrating in the mating season.

Reptiles

Traffic has been found to be less dangerous for reptiles than for amphibians. One reason is that reptiles do not migrate in masses and besides, their populations are usually smaller (Bakó 1999; Marián 1987). Another reason is that most reptiles – principally lizards – have a more effective avoiding strategy. Still, a lot of tortoises [European pond turtle (*Emys orbicularis*) in Hungary] and lizards (Sauria) fall victim to traffic.

The explanation lies in the fact that Hungarian reptiles are all diurnal, so high intensity daily traffic can cause considerable damage to their populations. The European pond turtle is outstandingly endangered, as it lives in freshwater but lays its eggs far from the water in sand or loess. The distance covered can be the order of a kilometre. Beside being slow moving, the European pond turtle is vulnerable also because of its poor defensive strategy (the animals retreat into their shell in case of danger). The young hatching from the eggs at the end of summer start migrating to the water nearly at the same time in great numbers. Traffic can cause considerable damages to a population in this case. Altogether there are two highly dangerous periods in the vegetative season of turtles. For similar reasons, but to a lesser extent, some snake species are also threatened: the Aesculapian snake (*Elaphe longissima*), the smooth snake (*Coronella austriaca*), the water dwelling dice snake (*Natrix tessellata*) and the grass snake (*Natrix natrix*).

Reptiles – primarily lizards and snakes – often creep to road verges or even onto the asphalt in order to warm themselves on the road surface which is hotter than the surrounding areas. These shrubby roadsides are often the most popular territories for some lizards [green lizard (*Lacerta viridis*), sand lizard (*Lacerta agilis*)] (Korsós 1982). Large amount of lizards fall victim to the drifting force of fast vehicles.

The greatest threat for reptiles, just like for other animal taxa, is the habitat segregation effect of roads especially for endangered species with small population sizes. A good example is a subspecies of the Danubian meadow adder (*Vipera ursinii rakosiensis*) living exclusively in Hungary, in the Hanság and Kiskunság regions, or the sand lizard *Podarcis taurica* in the Danube–Tisza interfluve. As a result of road construction the water supply of the nearby fens is also at risk. Since the common lizard (*Lacerta vivipara*) – a relict species of Hungary – is strictly confined to such habitats in the Kiskunság region, the fragmentation of fens results in a drop in their populations.

Birds

The endangering effects of traffic on birds (Aves) are principally direct, caused mainly by running over. Certain bird species are attracted by roads and get more often knocked down by cars. Seed-eating or granivorous birds [green finch (*Carduelis chloris*), goldfinch (*Carduelis carduelis*), hawfinch (*Coccothraustes coccothraustes*), etc.] may feed on grains fallen from cereal transporting lorries. Insectivorous shrikes [red-backed shrike (*Lanius collurio*), great grey shrike (*Lanius excubitor*), lesser grey shrike (*Lanius minor*), swallows and martins (Hirundinidae)] and small predators that chase small birds alerted by traffic [sparrow hawk (*Accipiter nisus*), kestrel (*Falco tinnunculus*), hobby (*Falco subbuteo*), etc.] often choose fences and other erect objects along roads as their watching places. In the eastern part of the country red-footed falcons (*Falco vespertinus*) are often seen sitting on posts along roads as they look for orthopterans over the roads. Buzzards (*Buteo buteo*) are also frequently found in winter sitting on the tip of lamp posts, watching small mammals. Although the above species are very good flyers, they frequently get run over by the modern fast and silent vehicles. However, more birds die by electric shocking during landing, sitting or flying through electric infrastructures (poles and wires).

After road constructions borrow pits filled with water are often left behind, which usually increase biodiversity. However, water birds (ducks, grebes, waders) are at risk due to the proximity of roads.

Heavy traffic roads might cross the flight route of bird species that nest in the wayside shrubby vegetation [tits (Paridae), pigeons (Columbidae)]. In such cases even flocks of birds may be knocked down.

Species that nest on the ground and fly low and slowly (partridges, pheasants) are also endangered by traffic (Lachlan 1976).

The probability of road kills greatly depends on the speed of vehicles. Birds have generally been observed to be incapable of avoiding cars travelling faster than 70–80 km/h. Thus, each type or section of road that carries cars running at a speed higher than this means a potential threat to birds.

Mammals

When discussing the effects of roads on mammals, distinction should be made between small mammals and larger game. The first group is less visible and has a poor avoiding strategy, while the latter has a more complex avoiding strategy and may even be potentially dangerous for passengers. Among small mammals, principally those feeding on animals or plants near roads are endangered by the direct effects of roads. The nocturnal Eastern hedgehog (*Erinaceus concolor*), some shrew species (*Sorex araneus*, *S. minutus*, *Clethrionomys glareolus*) or the common hamster (*Cricetus cricetus*) protected in Europe but pursued in Hungary, may all feed on the carcass of run-over animals. Hamsters, however, mainly collect grains fallen on the road surfaces, as do voles (Microtidae) and mice (Muridae).

The habitat fragmentation effect of roads primarily affects animals that avoid bare surfaces. Such mammals are the Hungarian dormouse species (Myoxidae) (Bakó 1996; Bakó *et al.* 1998; Morris 1997) and the water shrews [northern water shrew (*Neomys fodiens*), southern water shrew (*Neomys anomalus*)].

Bats (Chiroptera) can also frequently get run over at dusk by vehicles of high speed. Wire-fences generally used in Hungary are not suitable for the protection of small mammals either, as the animals easily climb through or over them. Frog-tunnels, however, are more frequently used by mice and voles than by frogs. Driving fences, on the other hand, are too low and do not hinder these mammals from climbing or jumping over onto the road surface.

Considering game run-over, roads leading through habitats permanently or temporally used by large populations are especially crucial. Such permanent habitats are extensive, contiguous woodlands (Mátrai 1996) and natural grasslands. Agricultural fields (maize, rape, cereals, etc.) may serve as temporal habitats for great numbers of game.

4.3. OVERVIEW OF FRAGMENTATION DUE TO DIFFERENT LAND-USES

State of nature, species and landscape diversity are basically affected by the land-use structure of the country, by the ratio of cultivated/abandoned land and by the extent of nature-friendly land-use practice within the cultivated areas. Figure 4.3.1. demonstrates the present situation in Hungary.

Changes in land-use accelerated after the middle of the twentieth century and – as a consequence – we can witness several, usually undesirable processes in the state of the landscapes of the country. Structure of the landscape had been altered as field sizes were increased for large-scale agriculture, while the formerly scattered, mosaic-like feature of landscape was transformed and the diversity decreased at the same time. Parallel with these processes the number of characteristic elements, unique landscape values were decreased. However, the radical changes in the conditions and practices of agriculture as a result of the political changes in the early ‘90s affected and are permanently affecting landscapes in a different way. According to the productivity fo soils and the new requirements of owners the major part of the formerly large-scale agricultural system becomes mosaic-like again. Area of uncultivated as well as of temporarily or permanently abandoned land is increased.

Among factors threatening or degrading landscapes of the country the following need to be stressed:

- ill-considered investments (agricultural and industrial plants, linear infrastructure) which were established without respecting the standpoints of landscape harmony in several places,
- the homogenising effect of large-scale agriculture and forestry, like the elimination of landscape elements (rows of trees, hedgerows, forest belts) that have previously increased the variability of landscape by ensuring diverse habitats,
- the expansion of built-up areas that is one of the unfavourable side-effects of infrastructure development.

The simplified impact matrix (Table 4.3.1.) helps to compare the effects of the different linear establishments on the land-use potential and on the habitat and landscape diversity of Hungary.

Table 4.3.1. Environmental impacts of linear infrastructures

	roads	railway	conduit	Product pipeline	Electric transmission network
Irreversible habitat destruction	+++	+	++	+	+
Reversible habitat destruction	++	+	+	+	+
Habitat fragmentation	+++	++	++	+	++
Altering amenity value of landscape	++	+	+	+	+++
Transforming surface features	++	+	+	–	–
Altering soil conditions	++	+	++	+	–
Changing microclimate	++	+	+	+	–
Modifying hydrological conditions	++	+	+++	–	–
Polluting environment	+++	+	+	–	–
Accidents and damages	+	+	++	+++	–
Sum of +	22	11	16	9	7

Key to classification: the effect is very significant = +++; significant = ++; moderate = +; insignificant = –.

Effects of fragmentation are different in different areas, for example in built-up and urbanised regions, in intensively cultivated agricultural lands or in quasi-natural habitats, forests or grasslands.

Fragmentation and urbanisation

Increasing the density of linear infrastructural networks in urbanised areas is a great pressure *and* an aspiration (required and wanted) at the same time. This contrasting interest manifests during the development of the road network: after reaching a certain level, the fragmentation effect of linear infrastructures becomes the drawback of further development by restraining the realisation of ecological and landscape requirements. Linear establishments support urbanisation at the beginning, while interfere with newer needs of inhabitants for more natural areas in built-up regions later.

Fragmentation and agriculture

Considering different aspects of fragmentation on agricultural production will lead to different judgements. On the one hand the linear structures break up agricultural lands and decrease field sizes, increase habitat diversity, the ratio of margin- and micro-habitats that all are very important (feeding, reproducing, overwintering, resting or corridor) habitats of many smaller-sized animal species. These areas also have outstanding importance from the point of view of bird protection (see partridge and great bustard survival projects, Faragó 1997). On the other hand the increasing length of accessing routes, closing crossovers, forcing power machines to roundabouts or longer passages belong to the disadvantageous effects of infrastructure. There are also indirect damages, among them the increase of environmental threats, the proliferation or pullulation of pests, the damage of nature, the pollution of agricultural products and others.

A great change in land-use, was initiated by the construction of the M7 Motorway that is connecting the capital and the greatest recreation area, the Lake Balaton. The opening of the main road increased the built-up ratio not only in the Balaton region but everywhere along the road from the Tétény Plateau through the margins of the Velence Mountains to the Lake. Great arable lands, extended vineyards and fruit gardens were abandoned and especially at the close vicinity of the motorway chaotic-like recreation plots and areas were evolved.

The railway line established first at the southern and later at the northern side of the Lake Balaton modified the land-use relations of the region. Viniculture and fruit production, reed management and fishery formerly all traditional to the region were entirely pushed into the background by tourism. Sight of the landscape has basically been changed. Built-up ratio has been multiplied and the natural shore line of the lake simply disappeared in most places. Traditional farming decreases at the same time the area becomes more and more overcrowded preventing recreation itself.

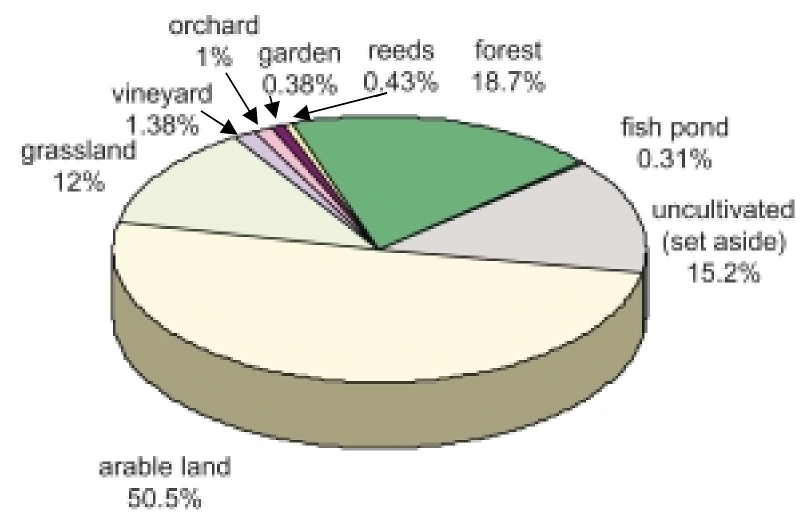


Figure 4.3.1. Break down of land-use classes in Hungary (Institute of Geodesy, Cartography and Remote Sensing, 1999)

Fragmentation and semi-natural habitats

As it was shown in the above table every linear infrastructure induces undesirable changes in semi-natural habitats. Distinction has to be made, however, within the different infrastructural elements depending on their size, capacity and realization. Fragmentation effect of earth tracks, footpaths, unpaved forestry tracks, narrow-gauge railway line is little and these linear structures do not cause basic changes in land-use. Covered roads and standard railway lines increase the accessibility of areas for the human population and in suitable conditions transform the former extensive or abandoned land-use types radically.

The driving force in developing certain regions are the roads, primarily the motorways. Road tracks remained constant for centuries – or even for millennia as the military roads of the Roman Empire in the Transdanubian region. Areas connected by public roads or nowadays by expressways were and are upgraded. Differentiation between regions or settlements by the existence or the lack of motorway connection has become common. The motorway increases the building and investment activity as well as further strengthens the transformation of landscape conditions. As a summary one can state, that with planning more intensive traffic, a higher speed and a shorter arrival time, motorways and railways become less adjusted to the landscape features and their fragmentation effect is the greatest.

In extended, closed forests the establishment of standard-gauge lines resulted in the development of marginal habitats with different species composition and lower biodiversity and in the alteration of water regime and microclimate. A good example for this process is the environment transformation made by a natural gas pipe established through the floodplain of the Tisza. There a hardwood alluvial forest – an association disappearing from Hungary – was opened in a wide tract for the pipe. The opening of the alluvial forest altered the microclimate of the southern part and consequently the relict endemism snail species, the *Helicygona banatica* ssp. *hungarica* became extinct from the area.

The greatest impact on the grasslands and forests of Hungary were the big water regulation projects, the channel constructions in the past two centuries. Areas in the size of a region (Hanság, Great Hungarian Plain, Sárrét) lost the variability and diversity of their plant and animal life by “defeating nature” for the sake of gaining new croplands. Decades later the unexpected consequence was discovered: the majority of areas conquered from nature were not suitable for large-scale agriculture/crop production.

4.4. Administrative and legislative framework

4.4.1. Environment and nature protection

The 53/96 Act of Nature Conservation gives the framework of preserving natural values and natural areas, landscapes together with their natural systems and biodiversity. Beside the general regulations, the specific regulations of the 7th paragraph dealing with landscape protection give the rules of establishing linear infrastructure as follows:

7. § (2) For the purpose of preserving landscape character, natural values, unique landscape values and aesthetical features:

(a) the harmonisation of linear infrastructural establishments and appliances (installations) to the landscape has to be ensured during construction by functionally and aesthetically reconciling natural values and artificial environment;

(g) motorways and other linear establishments crossing known movement corridors of wildlife need to be constructed in such a way that allows in suitable intervals the individuals of wildlife species to cross it;

(h) subsistence of characteristic landscape elements needs to be assured.

The Law of Nature Conservation effective at present allows stronger protection to non protected areas than the earlier legal measures by defining the concept of natural areas (forest, grassland, reeds, areas withdrawn from cultivation, as well as lands not suitable for farming or forestry) in paragraph 15. and by restricting the activities in these areas, among them the linear investments.

Similarly to the earlier regulation, the nature conservation authority is the legal authority in the licensing procedures of establishing linear infrastructures on/through protected areas (paragraph 39. of the Law). With the exception of nature protection management, all activities, among them the establishment of linear infrastructures are forbidden on strictly protected areas.

The structure and organisation of the national body of nature conservation are prescribed in paragraphs 56–58: the Minister of Environment supervises the nature conservation activities. Administration tasks of nature conservation belong to the National Authority for Nature Conservation supervised by the Minister at the second instance and at first instance to the national park directorates or to local governments (in case of areas or values protected at local level). There are nine national parks in Hungary at present. Areas belonging to the different national park directorates and their basic data (registered also in the nature conservation inventory) are shown in Table 4.4.1.1. and in Figure 4.2.4.2.

The 53/95 Act of Environmental Protection orders that before starting any activity significantly affecting the environment, an environmental impact assessment has to be prepared (paragraph 67). Activities falling under the scope of this regulation as well as the detailed administration procedures are prescribed in Government Decree number 152/1995. (12. Dec.) which lists among others the following linear establishments that need preliminary impact assessment:

- public railway,
- motorway, expressway,
- primary road,
- secondary road if driven across forest greater than 50 hectares,
- underground railway,
- oil pipeline, natural gas pipeline, oil-product pipeline,
- main irrigation canal if not covered,

and moreover in protected natural areas of national or local importance:

- aerial cable,
- road for permanent use,
- railway for agricultural and forestry purposes,
- underground/subsurface conduits.

Status of nature conservation in Hungary

One of the principal aims and tasks of nature conservation is the establishment of the network of protected areas. Since the designation of the first protected areas – more than a half century

Table 4.4.1.1 Most important data of national parks

No.	Registration number	National park	Extension of protected area (ha)	Nature conservation manager
1	177/NP/85	Aggtelek NP	19892.0	Aggtelek NP Directorate
2	282/NP/97	Upper-Balaton NP	56997.8	Upper-Balaton NP Directorate
3	138/NP/76	Bükk NP	43129.8	Bükk NP Directorate
4	271/NP/96	Danube-Dráva NP	49473.0	Danube-Dráva NP Directorate
5	283/NP/97	Danube-Ipoly NP	60314.1	Danube-Ipoly NP Directorate
6	238/NP/91	Fertő-Hanság NP	23588.2	Fertő-Hanság NP Directorate
7	97/NP/73	Hortobágy NP	80548.9	Hortobágy NP Directorate
8	109/NP/74	Kiskunság NP	56761.0	Kiskunság NP Directorate
9	276/NP/97	Körös-Maros NP	50134.0	Körös-Maros NP Directorate

Source: National Authority for Nature Conservation, Ministry for Environment

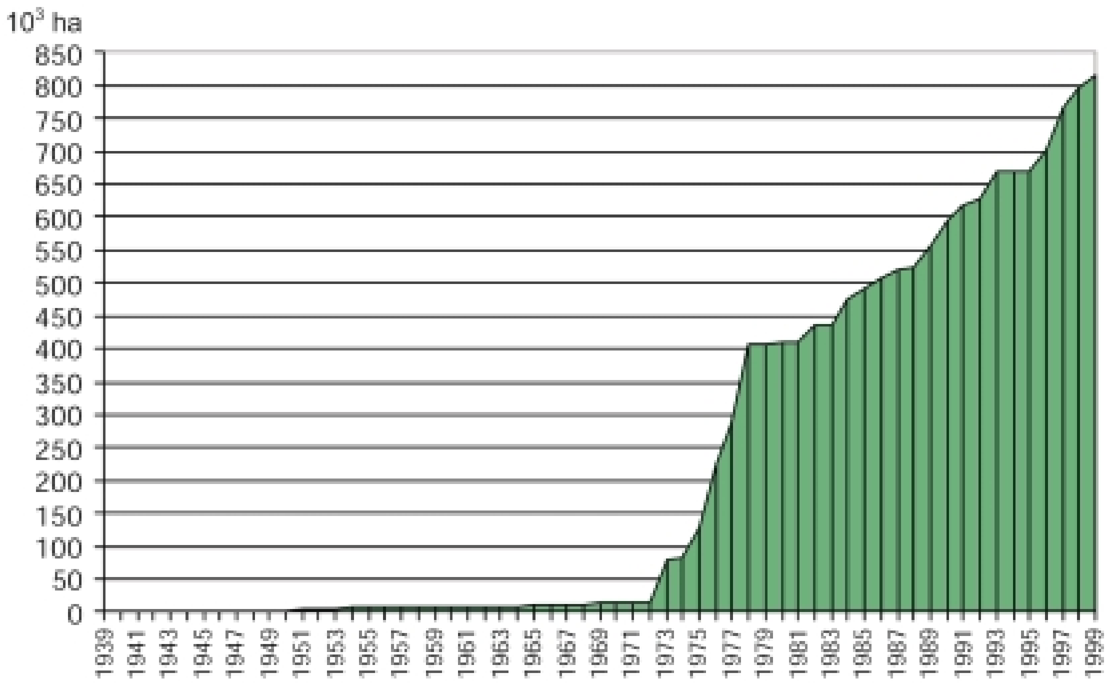


Figure 4.2.4.1. Extension of protected areas of national importance between 1939 and 1999

ago – important steps have been made forward in the field of nature conservation. In 1939 the government designated 273 hectares for protection within the present territory of Hungary. That area increased to 630.124 hectares till 1990 and to 849.749 hectares till January 2000, representing 9.1% of the territory of Hungary (see Figure 4.2.4.1). 11–12% of the country area is the target for protection by legal means in the long-term.

Table 4.2.4.1. Trends in number of protected species of different taxonomical groups between 1990 and 2000

	Number of known species of the world	Species number in Hungary	Protected			Strictly protected			Altogether		
			1990	1994	2000	1990	1994	2000	1990	1994	2000
PLANTS	350000	3000	415	454	464	31	47	52	446	501	516
Mosses	25000	589	19	20	20	0	0	0	19	20	20
Pteridophyte	13000	60	27	38	38	0	1	1	27	39	39
Gymnosperms	640	8	0	1	1	0	1	1	0	2	2
Angiosperms	311360	2343	369	395	405	31	45	50	400	440	455
ANIMALS	1250000	42016	573	781	771	46	76	84	619	857	855
Invertebrates	1205000	41460	180	398	389	0	0	0	180	398	389
Vertebrates	45000	556	393	383	382	46	76	84	439	459	466
Cyclostomata	*	*	0	0	2	0	0	0	0	0	2
Fishes	22900	81	26	28	25	0	0	1	26	28	26
Amphibians	3000	16	16	16	16	0	0	0	16	16	16
Reptiles	6300	15	13	13	13	2	2	2	15	15	15
Birds	8700	361	289	275	278	38	65	70	327	340	348
Mammals	4100	83	49	49	48	6	9	11	55	58	59
ALTOGETHER	1600000	45016	988	1235	1235	46	123	136	1065	1358	1371

* no data

The greatest part of designated land is protected at a national level and the nine national parks themselves represent 440.839 hectares among them. There are 38 protected landscapes with an extension of 349.242 hectares altogether, 109.577 hectares of which are under strict protection. The most rigorous management and visit regulations operate at strictly protected areas. 1067 sites are protected at local level and their extent is altogether 35.800 hectares. The most important nationally protected areas are shown in Figure 4.2.4.2.

It is worth mentioning here, that since the middle of the seventies a continuous and gradual consolidation of nature conservation could be witnessed in Hungary. Since that time the designation of protected areas has been accelerated (see Figure 4.2.4.1). The first national park was founded in 1973, three others were established and the foundation of the fourth was prepared till 1990. This progress successfully continued after the political changes and the extension of protected areas approaches 850.000 hectares in 2000. Meanwhile the countrywide network of 9 national parks was established (and is working with the guidance and supervision of the nine national park directorates).

Protected natural values without protected location

The protected natural values without defined area are the protected plant and animal species, natural monuments, unique landscapes and protected values like fens, caves, etc. The present study deals only with protected species from the above listed entities.

The first species were protected at a national level in 1982 in Hungary. The first protected species lists aspired to reach a "minimum list", protecting the most important plant and animal species at least. During the past almost twenty years the lists were more times amplified and in 1996 they were considered to be scientifically correct and complete concerning higher plant species and animals. Lists need periodical revision for including new scientific results. Even in medium time scale the status of a given species may change so much – owing usually to the achievements of nature conservation – that the status of the species is worth changing in the legislation. Other plant or animal species can become scarce or even frequent on the opposite. For example the formerly very rare cormorant (*Phalacrocorax carbo*) became frequent in Europe thus was deleted from the protection list. However, the circle of protected species is not totally covered yet in Hungary because nature conservationists try to compile for example the list for mosses, lichens and fungi's lists at present. There are proposals for protecting plant associations and a detailed decsription of plant communities with proposals for protection initiated by the National Authority for Nature Conservation was published in two volumes in 1999 (Borhidi & Sánta 1999).

Plants

About 2400 higher plant species (together with the so-called microspecies) are living in Hungary (see Table 4.2.4.1.). The lack of precise numbers results from continuous debates about species/subspecies identification and of course from the most recent taxonomic researches. Sixty species belong to pteridophytes (2.0%), 8 are gymnospermous (0.26%) and 2343 are angiospermous (78.1%). 516 species of the flora of Hungary is protected at present, 52 of which is strictly protected. This means a respectable part, 17.2% of the flora. Among lower plant species, 20 *Sphagnum* species are also protected. Protected as well as several yet not protected rare species of high natural value are actually or potentially endangered with some exceptions. These species/populations can be preserved exclusively by the maintenance of their habitats. This is true even if many examples prove that they can be reproduced in horticultural/botanical gardens. The importance of "cultivated" stocks is their potential in strengthening and increasing the original (endangered) populations at the original habitats.

Animals

Among the 81 fish (Pisces) species of Hungary 26 are protected and the only strictly protected species is Danube trout (*Hucho hucho*). All the 16 species of amphibians are protected there is no strictly protected amphibian in Hungary. Similarly all 15 species of reptiles of Hungary are protected, two of which, the green whip snake or racer (*Coluber jugularis*) and the meadow viper (*Vipera ursini rakosiensis*) are strictly protected. 348 of the 361 birds of Hungary are protected and 70 of them are strictly protected. 59 of the 83 mammal species are protected and 11 of them are strictly protected. Altogether 389 invertebrate species are protected in Hungary at present.

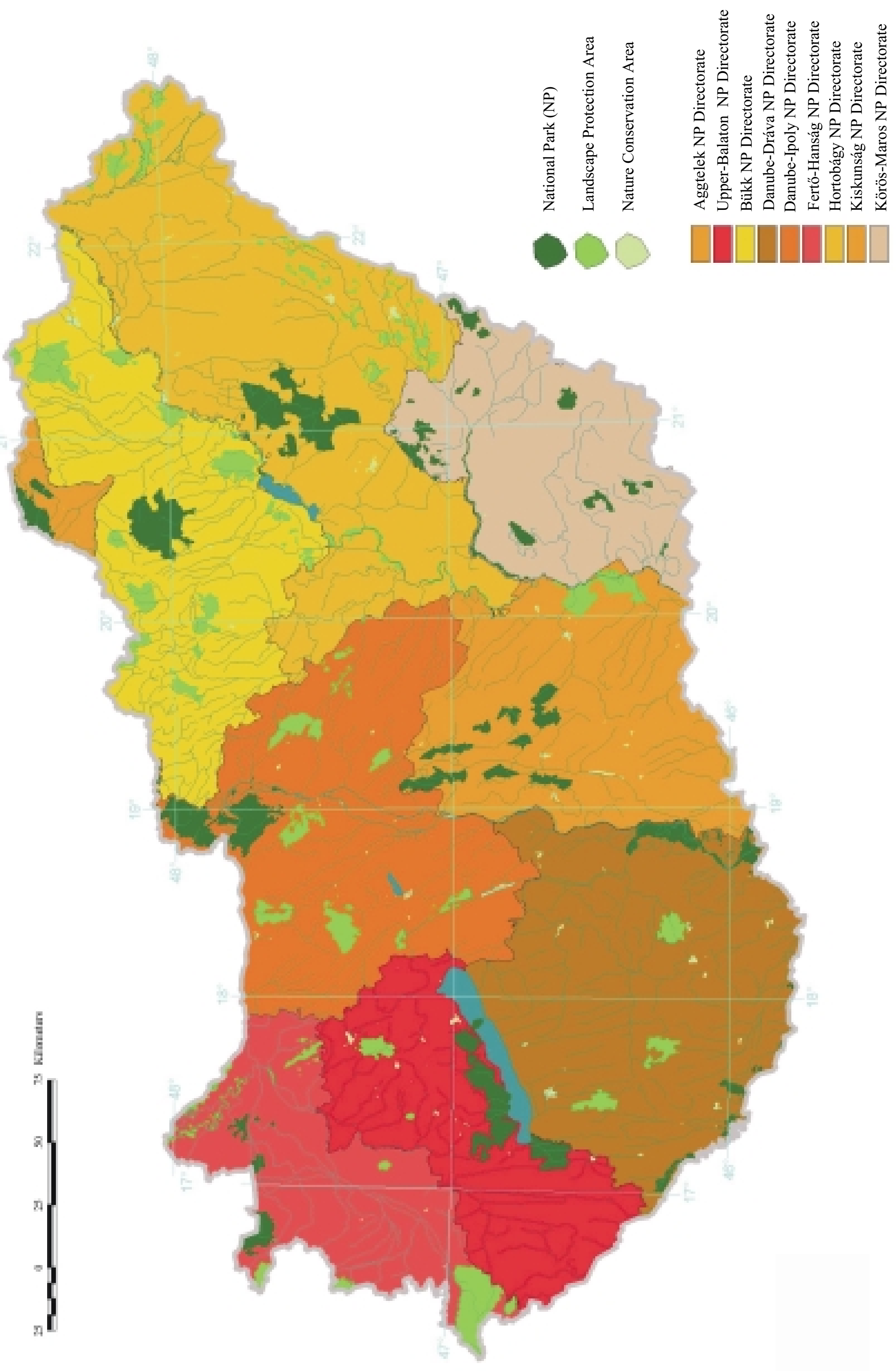


Figure 4.2.4.2. The most important protected areas of Hungary (map by RISSAC, data source: National Authority for Nature Conservation, Ministry for Environment)

Habitat protection

Single species – plants or animals – can not be preserved successfully. Only species together with their habitats are possible to protect. Physical and biological elements of habitats serve as important environmental factors for species (e.g. the different plant associations and the different physical surface elements are the scenes/subjects of breeding, feeding, wintering, resting activities of animals). Communities of living organisms are mainly determined by their plant associations (fundamental units of the flora).

Today 470 plant associations are registered by botanists within Hungary. 350 of them can be considered natural and semi-natural associations and about 120 are of antropogenous origin 114 of which are markedly weedy associations. Not less than 218 associations, 62% of natural and semi-natural associations require basic or higher level protection (Borhidi & Sánta 1999).

National Ecological Network

The elaboration of the National Nature Protection Strategy as part of the National Environment Protection Strategic Plan was ordained in the Paragraph 53. of the Law of Nature Conservation (53/1996). The aspects of establishment and maintenance of a National Ecological Network are included in the above mentioned strategy. The National Nature Protection Strategy was submitted to the Parliament and passed in 1997. Afterwards – with the overall co-ordination of the National Authority for Nature Conservation of the Ministry for Environment – the National Park Directorates elaborated the plan of the National Ecological Network in the scale of 1:500.000 (see Figure 4.2.4.3.), in accordance with the regional regulation principles of the Regional Policy Plan of Hungary.

During the elaboration of the National Ecological Network – beside following the Hungarian regulations – the following international agreements of outstanding importance (and their deadlines) had to be considered:

Pan European Biological and Landscape Diversity Strategy. All signatory countries of the Strategy have to designate core areas, ecological corridors and nature development areas (buffer zones) within their national ecological network (as the directives of the competent committee of the Council of Europe, April 1999 orders).

The areas belonging to the EU “Natura 2000” ecological network, such as the “Special Protection Areas – SPA” (regulated by the bird protecting directive no. 79/409 of the EEC), as well as the “Special Areas of Conservation – SAC” (ordered by the EEC directive no. 92/43 for habitat protection), and the habitats of threatened species or species requiring special protection of the EU all are parts of the National Ecological Network.

The national park directorates have recently finished the compiling the map series (scale 1:50.000) of the regional ecological networks. The international outstanding significance of the regional ecological map series lies in the fact that it intends to meet requirements and to use elements of the above mentioned two systems.

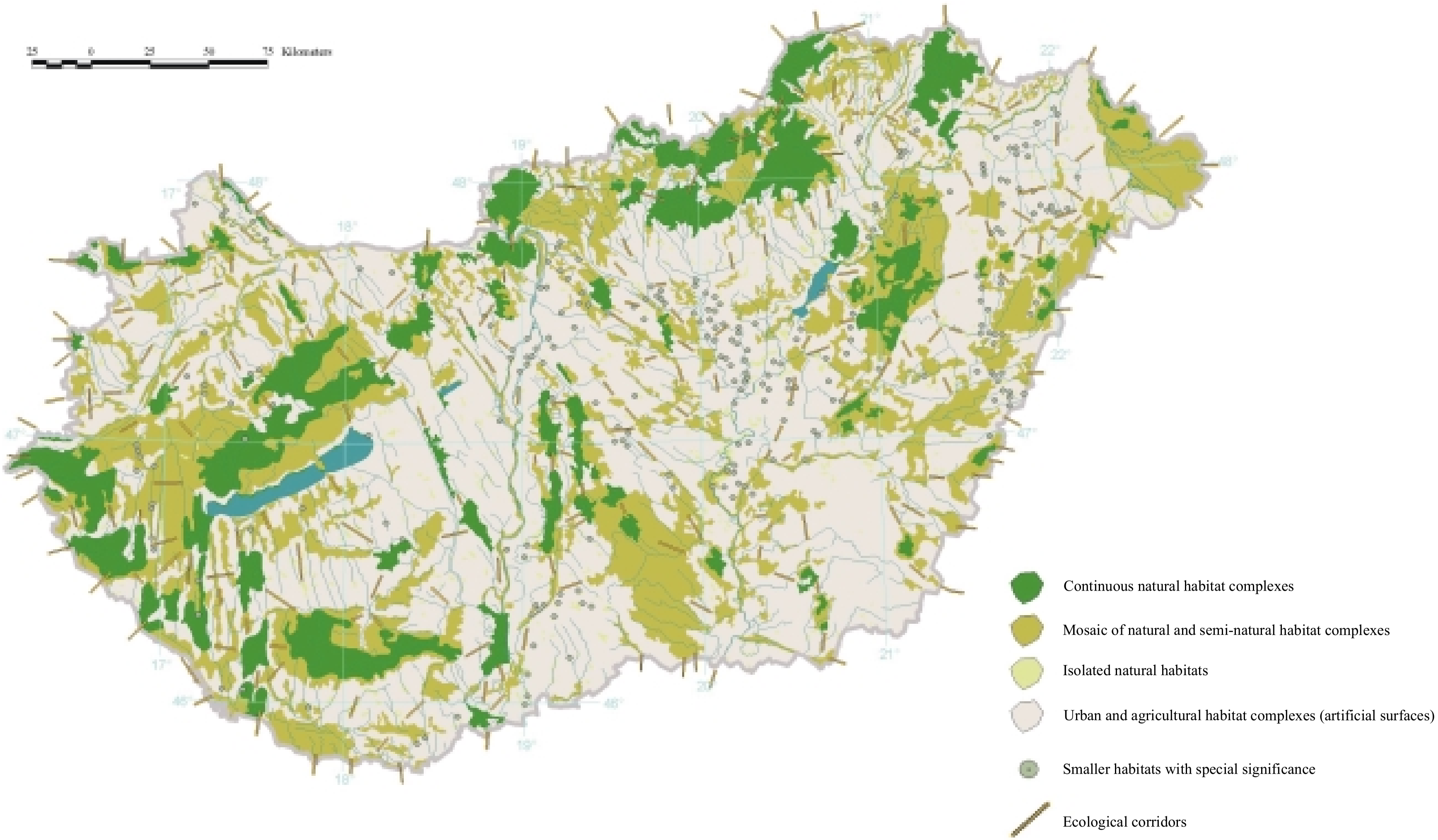


Figure 4.2.4.3. National Ecological Network of Hungary **(map by RISSAC, data source: National Authority for Nature Conservation, Ministry for Environment)**

4.4.2. Administrative and legislative framework for traffic and transport

Surface roads

The Law of Traffic on Public Roads (1. of 1988) deals with developing public traffic (paragraphs 10. and 11.). The law laid down the principles that "road development plans and regional/local development policies should be coherent. Roads need to be developed in the way that public roads (national and local public roads) and open private roads form a continuous system." During developing the road network the traffic and transport requirements should be the prime factor, and among others, the interests of environment and landscape protection have to be considered as well.

This law orders that "an independent, special policy plan of developing the national network of roads has to be elaborated, and submitted for approval to the Government by the Minister of Transport, Communications and Water Management".

The following framework plans were elaborated for developing the public road system:

- National road development plan, which deals with the development concept of primary, secondary roads and national road network.
- National motorway-expressway network development scheme – for motorways and highways.
- Roads maintained by local municipalities – only Budapest finished the plan of "Transport system development plan of Budapest". In the case of the other settlements the local regional planning policy includes the network development concepts.

Based on the listed framework, the road network managers are the decision makers in developments, they initiate planning projects. The designing engineers complete the plans according to the technical regulations. Among them the most important is the transport sectoral standard titled "Designing public roads" (ME-07–3713:1994).

Authorisation process for public roads

For roads included in policy plans a study (draft) plan is elaborated. The environmental protection plan is a compulsory part of the study plan. Depending on road type and areas affected a preliminary impact assessment has to be made parallel with the study plan. The route (layout) options of the impact assessment will be evaluated by – among others – the environment protection authority during the process of licensing. The layout for detailed road planning will be selected on the base of the opinions of competent authorities. The Road Management and Co-ordination Directorate approves the chosen trace in the case of important networking roads (national roads).

After first approval the detailed licence plan has to be submitted for confirmation to the road management authorities. The first instance administrative authority is the competent county traffic authority in the case of national roads and roads out of the capital and the Central Traffic Authority in case of highways. The environment protection agencies are the special assenting authorities for the environment protection chapter of the license plan, they issue the environment protection license for the detailed impact study, and they co-ordinate the work of other competent authorities on the impact assessment. The approval of all competent authorities is the minimum requirement for issuing the construction plan.

Railway

As the referring law (95. of 1993) defines, railway is a fixed track transportation system for transporting passengers and goods. Constituents of the system are the fittings of the railroad, the operating equipment and units, the railway vehicles and the working administration operating all above and implementing passenger and goods transport.

The law states that development of railroad transport is a state duty. The National Railway Statutes enacted by the No. 28/1994 (28. Oct.) Decree of the Ministry of Transport, Communications and Water Management order that railway development policy plans have to be made for the national railway network and to the main lines.

The line planning is based on the National Public Railroad Planning Rules, which lists the important aspects to be considered during planning public railroads, among them the long-term demands on development. Using land for railroad development purposes is allowed only in agreement with the regional plans, consequently railroad and other sectoral provisions of the regional plans have to be considered during planning.

Waterways

The Law of Water Resource Management (57. of 1995) contains the general rules and duties regarding waters and waterworks. The regulations of the Law cover primarily the water uses of water management and the conditions of them – in accordance with the Law of Environment Protection. Among activities affecting surface waters the mostly emphasised ones are flood prevention and inland drainage together with governmental and local governmental tasks regarding these. The Law does not treat water transport and related interventions.

4.5. LAND-USE PLANNING IN RELATION TO NATURE AND LANDSCAPE CONSERVATION AND TRANSPORT

The 21/96 Act on Regional Development and Physical Planning defines the country and regional development and planning duties and aims. According to the law the transport unit and the nature conservation unit are inherent parts of the regional policy plans. Regional development and planning purposes are prescribed in paragraphs 2/b. and 2/c. as follows:

Paragraph 2. aims of regional development and physical planning are:

- (b) "for the sake of ensuring the equal social chances: to moderate the significant differences in living conditions, economy, culture and infrastructural conditions between the capital and the country, the towns and the villages, or the developed and the backward regions and settlements; to prevent the evolution of new crisis areas,"
- (c) "to promote the harmonic development of the spatial structure and settlement system of the country".

Paragraph 23. defines the bases of regional planning: they are the regional development policy, the regional development programme and the physical plan. The physical plan – in accordance with the aims defined in the regional development policies – lays down the land-use method of the area regarded. It contains moreover:

- the spatial organisation of the regional technical/infrastructural systems,
- the long-term regional system of the area regarded,
- the appropriate use of the conditions of the given areas,
- the regional tasks concerning environment, landscape and nature conservation.

By paragraph 5. the regional development policy is a scheme that lays the foundation of and is the determinant factor of the overall and long-term development of the country or a region, which specify the long-term and general development purposes as well as the guidelines necessary for elaborating the development programmes and which support the participants of the sectoral planning and the related regional planning and development with information."

The No. 18/1998. (25. June) Decree of the Ministry for Environment and Regional Policy deals with the content requirements of the regional development policies, programmes and regional plans.

Content requirements of the regional development policies are defined in two phases namely it prescribes a preparatory and a proposing phase. The preparatory phase has three main parts:

- exteriors (external environment) of the regional unit,
- regional conditions (human resources, bases of economy, environmental factors, infrastructure, settlement network, social environment),
- possible directions of development.

Questions regarding infrastructure, its present status and possible developments have to be considered in both the preparatory and the proposing phase.

Settlement structure plans and physical plans are elaborated for the given settlement or settlement district. Physical plans and regional development policies are evaluated by different authorities (nature conservation, environment protection, transport and others), by public hearings and NGOs in certain cases. Physical plans and regional development policies serve as the base of following planning processes. In the case of planning a transport infrastructure divergent from the physical plan, the regional plan has to be modified.

The No. 35/1998 (20. March) Parliament Decree about the Regional Development Policy of Hungary defines the prospect of regional development policy.

The main features of the policy are:

- belonging to the community of the European states, Hungary serves as connecting corridor in east-west and north-south directions – in accordance with its cultural heritage, geographical features, and developed national economy,
- the regions of different social and economical conditions are developing in different individual ways with intensive co-operation and in harmony but not in dominant/subordinant relations with each other,
- the regional inequalities are being moderated, the number of disadvantageous regions with less developed social and economical conditions and with high unemployment ratio are being declined,
- the urbanisation axes and traffic corridors are integral parts of the European spatial structure and they are dynamic elements of regional development.

Important environmental priorities in the area of regional development are:

- one of the most important purpose of regional development is ensuring maintenance and improvement of the environmental factors required for acceptable living qualities especially in the regions with high environmental pollution level,
- for the purpose of preserving the optimum state of environment the effects of transport corridors, financial and trade networks, multinational bodies, energy transferring networks and transit on the unique ecosystems of the Carpathian Basin have to be regularly surveyed and evaluated,
- regional development has to be realised by preserving natural systems, natural values and biodiversity,
- regional development plans should be shaped and realised in the way they utilise wisely and harmonically the environment; the conditions of which are the enforcement of principles of sustainable development as well as the long-range maintenance of the optimal state of environmental factors considered to be of vital importance (air, water, arable land) while using/managing natural resources.

Important technical infrastructural priorities of regional development:

- construction of freeway network, modernisation of railway network, development of waterways of the Danube and the Tisza have to be accelerated for the purpose of improving the access of regions and better utilisation of the advantages of the country coming from its favourable geographical location,
- the development of airports suitable for regional development (partly in form of private investments) should deserve greater importance,
- for the sake of decreasing the environment pollution the role of combined transport of goods, water-carriage and rail transportation have to be increased and logistic centres at the regions of the internationally most important border stations have to be established,
- circle route (by-passing) programmes relieving settlements from high traffic load have to be continued,
- quality and level of mass public transportation have to be improved in the future as well,
- in accordance with the traffic and transportation policy of the European Union the transport infrastructures connected with the European traffic corridors crossing Hungary (No. 4., 5., 5/C., 7., 10/B.) have to be developed.

4.6. SUMMARY

Natural status of Hungary is really favourable comparing to several Western European countries. Deriving from its biogeographical location the biodiversity is high from the outset on the one part, while the relative underdevelopment of infrastructure caused less damages in nature in the past years than in the well-developed Western European countries on the other. The growing knowledge of ecology, the strengthening of conservational awareness and the legal regulations reflecting all above – at least theoretically – create the challenge of bypassing the extended nature destruction found regularly in other countries. For a better understanding the natural regions of the country, their values, characteristic land-use types, habitats and their sensibility as well as certain aspects of fragmentation effecting habitats were drafted in this chapter together with the status of administration and relating legal regulation.

Chapter 5. Habitat fragmentation due to existing transportation infrastructure

5.1. Introduction

By Western European measures there are only few special publications dealing exclusively with the environmental effects of the inland transportation network in Hungary and publications with some demonstration regarding this topic can hardly be found. Possible reasons of this scarcity are:

- the past and partially the present lack (missing enacting clause of the act) of relating legal regulations,
- the lack of financial resources in every sectors, among them in the field of environmental protection,
- increase of environmental consciousness has developed only in the last 10–15 years,
- basic researches were and are in delay because of lack (legal, financial and ethical) support.

A comprehensive and countrywide study regarding habitat fragmentation effects of the road network was made within the frame of this COST 341 project by the Research Institute of Soil Sciences and Agricultural Chemistry (RISSAC), at first in Hungary (results are shown in case study no. 3).

An investigation about the environmental damages caused by the inland railway transportation was made in 1995. However, this study did not concern the effects on nature. Total railroad length is 12.749 km (source: Hungarian Statistical Year-book, 1998), about an eighth of the road network. The only permanent fairway of Hungary is the Danube (inland length is 415 km), while the Tisza (the Hungarian section is 595 km long) is partially navigable. Both waterways are natural water currents thus no habitat fragmentation effect is expected.

5.2. Transportation network of Hungary

The spatial structure of Hungary is dominated by a centralised transportation network with the capital, Budapest in the centre (Figure 5.2.1.).

Common country level feature of both the road and the railroad transportation system is the lack of transversal connecting elements, namely the corridors (of suitable capacity) between eastern and western regions which – at the same time – would relieve Budapest and its Danube bridges. This feature results in the overburden of roads going to and from Budapest on one side and in the lower than possible level of cooperation between the two parts of the country separated by the Danube. These difficulties in the transportation system originate from the Trianon Decree (1920), that resulted in the loss of peripherial connections.

5.2.1. Public roads

The road is a public or private domain serving the pedestrian and the vehicle traffic. The road network is the continuous system of national roads and roads of local governments.

Motorways connect countries or regions. These trunk-roads establish long-distance transport corridors for the most intensively used routes of international and national importance. They provide the highest service level and are made exclusively for the use of motor cars. They have

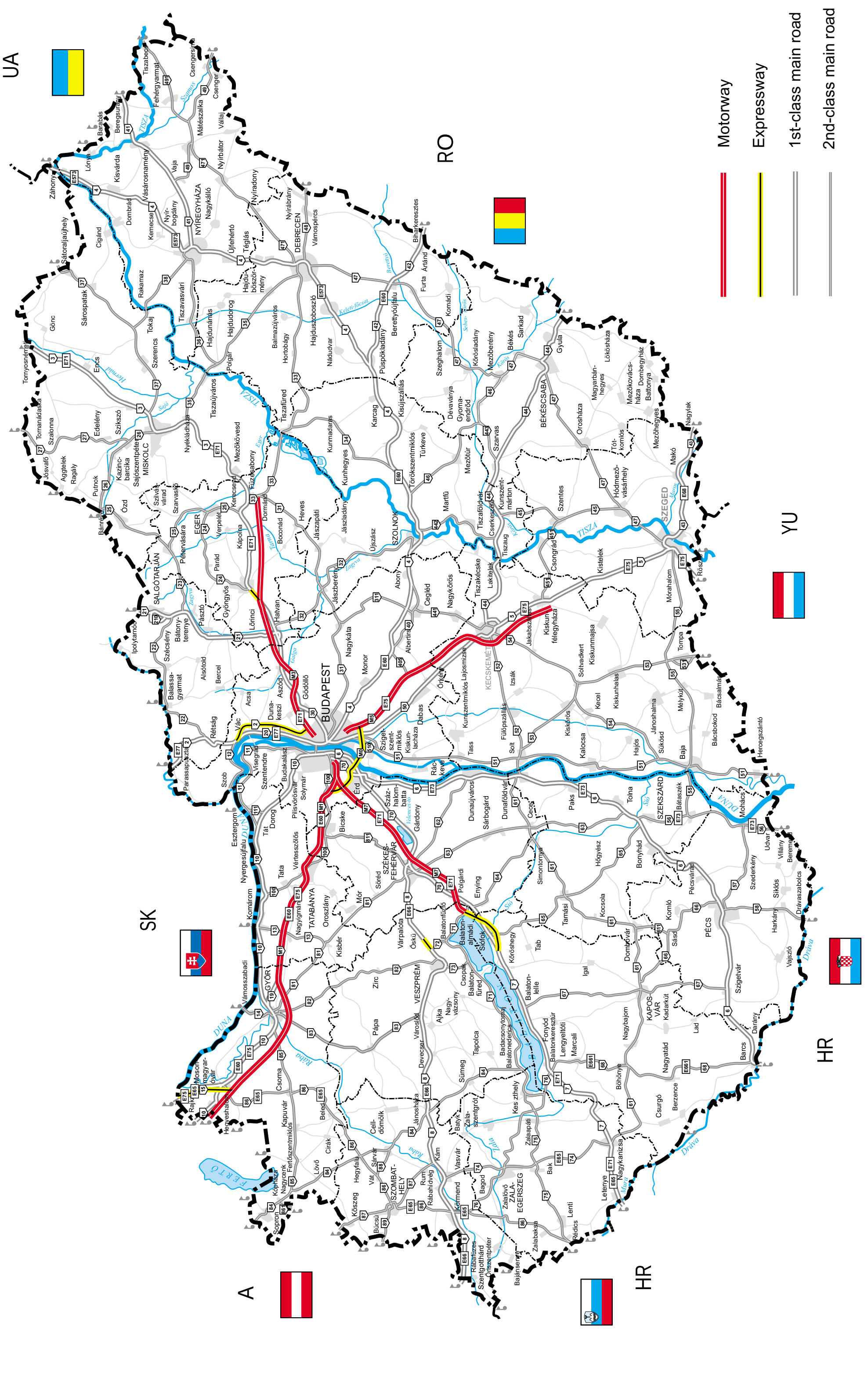


Figure 5.2.1. High-speed and main road network in Hungary

at least 2×2 traffic lanes, a central reserve separating traffic to different directions and a hald-shoulder on the right side of the double lanes (except of special places). Motorways have no crossing at grade in any type of intersection with transportation routes. A separated lane is to be made for the converging or the diverging (merging) traffic in the flyover junctions. It has no exit to properties along the road.

Expressways interlink regions of the country. These roads are made for greater-distance traffic needs, have at least 2×2 traffic lanes, have no level crossing with railway. Their intersection with other roads of intensive traffic is to be realised at split level. At grade junctions expressways usually have separate lane for left exit. For ensuring the movement of slow-moving vehicles a parallel service road or other designated road should exist with separate grade crosses in places where necessary. Expressways have no exit to properties along the road.

Primary roads interlink regions, important agglomerations or recreation areas which have usually two lanes but may have more lanes in sections of high traffic. Newly planned or newly reconstructed sections have no level crossing with railway. Junctions within sections of wider than two lanes are grade separated. At grade junctions primary roads usually have separate lane for left exit. For ensuring the movement of slow-moving vehicles a parallel service road or other designated road should exist. They have no exit to properties along the road.

Secondary roads have distributor role within regions. They may have exit to properties along the road exceptionally.

Through roads are made for serving the through and greater local transport with their distributor role within smaller regions (mesoregions).

Table 5.3.1. Summary status of Hungarian road networks [km]

	Settlement territory			Outskirts			Road network together		
Character of network	Built up	Total	Built up %	Built up	Total	Built up %	Built up	Total	Built up %
NATIONAL ROADS*	8398	8403	99.9	21514	21842	98.5	29912	30245	98.9
Main network	1486	1486	100.0	5501	5501	100.0	6987	6987	100.0
Secondary network	6912	6917	99.9	16013	16341	98.0	22925	23258	98.6
LOCAL ROADS**	32148	50545	63.6	3681	54688	6.6	35828	105233	34.0
Main network	(1408)	2575		(529)	3306		(1937)	5881	
Secondary network	(21044)	47970		(1088)	51382		(22132)	99352	
PUBLIC ROADS	40546	58947	68.8	25195	76530	32.8	65741	135478	48.5
Main network		4061			8807			12868	
Secondary network		54886			67723			122610	
PRIVATE ROADS				16206	52919	30.6	16206	52919	30.6
Private agricultural road				13670	48000	28.5	13670	48000	28.5
Private forestry road				2536	4919	51.6	2536	4919	51.6

* of Dec. 31.,1998.; ** of Dec. 31.,1995. (the 50/92 Act ordered to transform the ownership of cca. 25.000 km long private roads to municipalities).

Side-roads are the roads not shown in the trunk road network of the country and all other roads except of cycle tracks and pathways.

Forestry private road support mainly the forestry needs. Permanent forestry roads together with their roadside ancillaries belong to forestry establishments. The general road traffic rules are valid in the case of forestry roads as well with the amendments of the Law of Forests and Forestry (no. 54/96).

5.2.2. Railway

The railway network of Hungary is of standard gauge (1435 mm). Typical gauge width of narrow-gauge railway is 760 mm while forestry railways are of 600 mm gauge. Narrow-gauge railways serve economical and recreational purposes.

Public railways may be classified by their network function and by transportation importance:

Category A.1. – international trunk lines

Category A.2. – national trunk lines

Category B.1. – other main lines

Category B.2. – side lines

Category C.1. – side lines with prohibited development

Category C.2. – side lines to be closed down.

Technical aspects of the planned line are determined on the base of the above classification. Important technical conditions are the followings: speed, axle load, free length of platforms and of tracks receiving arriving trains, permitted load, number of open tracks, type of pulling, system of saving means. Design speed for the different line classes is:

Category A.1. 160– 200 km/h

Category A.2. 120–160 km/h

Category B.1. 100–120 km/h

Category B.2. 60–80 km/h

5.2.3. Waterways

Inland waterway transportation is allowed on the following water bodies:

- natural water currents and lakes,
- regulated water currents and lakes,
- artificial channels.

Natural waters are navigable without any intervention. Regulated watercourses are those which can be made navigable by water engineering and regulating means. A water current is to be called canalised if the water depth necessary for shipping is ensured by barrage.

A waterway is artificial if a new bed is made for shipping purposes, i.e. in places with no or with only insignificantly little water current. If the exclusive purpose of making an artificial waterway is shipping, than this is a shipping canal. If it serves other interests as well (for example water transport, water supply) than this is a navigable canal. Waterways can be classified by their importance and tonnage of ships using them; we can distinguish waterways suitable for small-scale shipping and regular shipping.

Ships with tonnage between 2.5 to 100 tonnes are allowed to use small waterways, while ships on regular waterways may have a tonnage of 250–3000 tonnes or more.

5.3. Effects of the existing transportation network on nature

Only the effects of road network will be discussed in this chapter because no publication of acceptable quality was found about the railway network effects on wildlife in Hungary. Data on the present road network is demonstrated in the Table 5.3.2.

Table 5.3.2. Main data of the Hungarian public road network (national and local network is distinguished on the basis of ownership).

National network		Local network		Total	
Length (km)	Land cover (m²)	Length (km)	Land cover (m²)	Length (km)	Land cover (m²)
30 244	193 493	105 233	173 693	135 477	362 656

Source: Road Database of the Ministry for Transportation, Telecommunications and Water Management, 1998

5.3.1. Habitat loss

One of the unfavourable results of fragmentation is the increasing edge-effect. Species and their ecosystems face with more severe environmental conditions at the edges of their habitat (considering their tolerance). Edge effect is greater if the proportion of edges to total habitat area is greater. Among two-dimensional geometrical shapes the circle has the shortest proportional edge, and the most elongated rectangle has the longest. Explanation is the same for the advantages of a greater patch contrary to a smaller one.

An investigation was carried out in this COST project to assess the risk of fragmentation of habitat types in relation to the present road network.

If we consider the average patch size of a habitat without and with the presence of a road which index reflects the fragmentation potential of the road, we can conclude that the extent of fragmentation and the threatenedness of habitats to fragmentation are directly related.

GIS was applied to estimate the fragmentation effects of the Hungarian road network. The following data sources were used:

- CORINE Land Cover database,
- Forestry maps (University of Sopron),
- Agro-topographical database (Environment and Landscape Management Institute, St. Stephen University),
- road network,
- habitat sensitivity estimations (see Table 4.2.1.).

The analysis was carried out for the following habitat sensitivity classes: low, medium, high sensibility types. With the help of GIS methodology, patch sizes of habitat classes have been calculated with and without the road network. The shape of the patches was taken into consideration by comparing the area/contour ratio to geometrical shapes of the same area (circle, square, rectangle with size ratio 1:2 and 1:4).

Habitat fragmentation risk is demonstrated in Figure 5.3.1.1. Patch size for different habitat sensitivity classes changed differently with taking the road network into consideration: average patch size became 71% of that of the situation with no roads for the low sensibility types, 90% for the medium, and 91% for the high sensibility types.

These results demonstrate well the fact, that the most sensitive habitats are more or less avoided by the road network (protected areas). The analysis of patch shape showed differences in relation to sensitivity: the least sensitive habitats are elongated (the highest resemblance to rectangle with side ratio 1:4), the habitats of the other two categories are mostly square shaped. The fragmentation risk of grasslands and forests differ: the sensitive grasslands and wetlands are more threatened by roads than forests. This correlates well with the fact that valuable forests are situated in the mountain zone or alluvial area, where a dense road network is unlikely to be placed. It can be stated, that the natural values of Hungary are moderately threatened by the fragmentation effects of the present road network, conservation efforts have to be focused on sensitive grasslands and wetlands.

5.3.2. Disturbance

The disturbing and damaging effect of operating roads and motorways can be manifold, their detailed summing up is beyond the scope of this study. A case study below represents the possible disturbances of roads on the living environment.

Case study no. 1. BIOLOGICAL MONITORING ALONG THE M0 EXPRESSWAY, SECTION 0–14 KM – A SUMMARY REPORT

By A. Bankovics, O. Merkl, F. Németh and O. Pallag

The construction of the studied section of the M0 expressway, that should be provide a by-pass around Budapest for transit traffic was started in the second half of 1992. The road was opened in 1995. The aim of the investigations was to identify the damages caused by the construction and operation of the studied highway section on the natural values of the surrounding area.

Study areas

Sample sites of the observation system for nature protection were (are) situated in natural or semi-natural habitat types along the studied route. One suitable site was the mixed oak forest (*Quercetum petraeae-cerris*, with sessile and Turkey oaks) at Mount Anna of Törökbálint, the other was the grassland at the edge of Tétény Plateau near Diósd. A detailed vegetation structure study was formerly planned by the researchers for evaluating the degradation resulting from the constructions. After two sampling surveys the grassland site was destroyed and thus botanical data of this site are excluded from this case study.

Botanical results

Monitoring higher plants on Mount Anna of Törökbálint

No significant differences were found in the plant species lists of 1990 and 1995 of the mixed oak sample site. The slight fluctuation recorded here can be defined as normal for this habitat. The appearance of some photo- and xerophilous species is worth mentioning at most. Generally the disappearance of a species does not imply its extinction from the area, because it may survive in hidden or hardly detectable form. However, striking changes could be observed in forest physiognomy and species mass relations (dominance) which both can be related to highway construction (the extent of changes was inversely related to the distance from road).

The most visible damage was the treetop defoliation type of forest damage. The dominant tree species, the Turkey oak was primarily affected in this way. The occurrence of treetop defoliation was more that 30% in the forest skirts of 10 to 20 metres wide, and was sporadic in the inner parts (more 50–100 metres from the skirt). The herb layer responded the most quickly to the changing light conditions: its cover increased to 75–100%, which is significant if compared with the estimated 30–50% cover previously. The biomass of several herb species increased greatly. Meanwhile some species became absolutely dominant (*Poa nemoralis*, and in less extent *Dactylis polygama* and *Alliaria petiolata*) most species seriously lost ground. Several new species emerged, some of them are especially disturbance tolerant species (e.g. *Euphorbia cyparissias, Muscari racemosum*) while others – in a much less number – are rare protected species (e.g. Illyr buttercup, *Ranunculus illyricus*). Invading ruderal weed species were not found to be characteristic although they can be found everywhere in the destroyed surfaces close to the forest.

The above phenomena may lead to the following conclusions:

Significant changes occured in the forest climate and/or in the soil water regime towards drying within the 5 years of the study. Tree damage increase the drying process and/or vice versa. The identification of the reason of tree damage would need a complex survey, however, the above mentioned constraints must have a major importance.

Intensive increase of herb biomass, among them the nitrophilous poor man's mustard (*Alliaria petiolata*) relates to eutrophication. It does not necessarily indicate direct nutrient input but rather the possibly increased mobility of soil nutrient supply or the increment of nitrogen fixation capability of the soil as environmental conditions have changed. Clarifying the background of the observed eutrophication would require complex studies.

As a consequence of tree damage, an increase in biomass of the more slowly responding shrub stratum (underwood) is expected parallel with the repression of herb layer, in which case the trends in species composition (biodiversity) can not be forecasted. This will transform the forest physiognomy in a greater extent and thus will lead to changes in the fauna as well.

After all the construction as a single intrusion restructured the sample plot so much, that the great structural changes probably hide the other affects of the highway operation (traffic) – certainly not including element accumulation in the nearby environment. Exploring the abiotic background and future processes of the structural changes can be an interesting basic research aim, but does not fall within monitoring activities.

Linear surveys of roadside (grass verge) vegetation

It has to be mentioned preliminarily, that no similar research was done anywhere in Hungary thus routine-like methods are not known. Consequently the study results may contribute in some extent to the development of road shoulder studies as well.

The survey was done on June 5, in 1995, at an optimal phase of the vegetation (complete summer vegetation aspect with identifiable spring and autumn elements). Full plant list was recorded for all sample sites. Rough biomass estimation was also carried out for given species, i.e. a species was considered to be abundant if it covered 50–90% of the plant covered surface. Dominant was a species which occupied more than 90% of the plant covered surface. The following results were found:

The extreme heterogeneity of the sample refers to the less organized vegetation and to its random character.

Dimension of homogenous vegetation patches fall in the decimetre-metre scale which is much less or is at around the characteristic area for the given species.

The plant ecosystem is unformed and unsettled, its structure is loose and no deeper investigations of structure is worthwhile.

Trends in species composition are more interesting. The 109 recorded species can be classified as mmber of the following community types:

- disturbance tolerant species of natural ecosystems (z, 38 species),
- weeds of abandoned and arable lands (p, 26 species),
- pioneer vegetation (weed-like, ruderal) of devastated surfaces (d, 18 species),
- nitrophilous weed communities (n, 11 species),
- cultivated species of plough-lands (k, 10 species),
- trampled weed communities (t, 5 species),
- species planted to cope soil erosion on roadside slopes (r, 1 species).

Despite that survey results were very different both in species numbers (ranging 0–42) and in species composition, the whole highway section can be characterized by a basic vegetation type. Eight species occur in more than the half of the sampling quadrats and with one exception all of them were semi-dominant or dominant in several samples:

- *Matricaria inodora* (a wild camomile, d), in 13 samples,
- *Polygonum aviculare* (prostrate knotweed, t), in 12 samples,
- *Lolium perenne* (common ray, t), in 11 samples,
- *Brassica napus* (rape, k), in 10 samples,
- *Festuca rubra* (red fescue, r), in 10 samples,
- *Lactuca serriola* (wild lettuce, d), in 10 samples,
- *Ambrosia elatior* (ambrosia, p), in 9 samples,
- *Apera spica-venti* (a grass species, p), in 9 samples.

The above 8 species well reflect the origin of the flora of the road bench as well as its ecological characters and population dynamics.

The greatest group of the total plant list is the disturbance tolerant species of the natural flora (i.e. the non obligate weeds). These species are usually not abundant individually. More numerous appearance is expected in areas where natural vegetation has survived road construction in a neighbouring or close habitat patch. However, some more rare plant species undoubtedly arrived to the sample sites “on the road”, e.g. the *Vulpia bromoides* spreading from Western Transdanubian and the *Puccinellia distans* the settlement of which is probably supported by the salt spreading on roads in winter.

Vegetation at the noise reducing walls (noise screens) is extremely poor, especially in the sections where both sides of the road is protected against noise (12–13th km sections). This fact is a definite evidence of colonization routes of road shoulders, i.e. that colonizing propaguls arrive mainly from lateral directions, while longitudinal colonization direction is of much less importance (however, in the case of cultivated and some other species this might be the prime migration direction). Poverty of the noise screen feet vegetation can be caused by the unfavourable microclimate and by the accumulating contamination.

Invasive species of Hungary as *Apera spica-venti* and *Ambrosia elatior* (ambrosia) are numerous in road benches as well, in spite of the fact that this habitat does not fall within their ecological optimum. The significant factor is the seed input in their case, as well as in the case of *Festuca rubra* (red fescue), planted locally for avoidance of soil erosion and in the case of cultivated species expanding their area by transport.

As a summary, one may state that vegetation of the road verge suffers the most from pollution and has successful adaptation mechanisms. This vegetation is an ideal subject for element accumulation monitoring, for genetic (enzyme polymorphism) investigations and for studying the biochemistry of antidote to poisoning. Several abundant species of this habitat, like *Polygonum aviculare* (prostrate knotweed), *Poa compressa* (Canada bluegrass), *Chenopodium album* (white goosefoot) have obvious morphological signs of high genetic diversity.

Zoological results

Quantitative analysis of avifauna, Mount Anna of Törökbálint

The breeding bird community of the Törökbálint site was characterised by the strong dominance of six species during the status survey (May, 1992). The blackbird (*Turdus merula*) and the robin (*Erithacus rubecula*) were dominant on the ground and shrub levels, blackcap (*Sylvia atricapilla*) dominated shrub and canopy levels, golden oriole dominated (*Oriolus oriolus*) only the canopy level while chiffchaff (*Phylloscopus collybita*) and chaffinch (*Fringilla coelebs*) the canopy and the ground levels (the former breeds, the latter partly feeds on the ground).

Several subdominant and colouring (glossy) species could be found on the area. Great tit (*Parus major*), blue tit (*Parus caeruleus*), song thrush (*Turdus philomelos*), tree pipit (*Anthus trivialis*), great spotted woodpecker (*Dendrocopos major*) belong to the former group. Correspondingly to their natural density, there are only a small number of turtle dove (*Streptopelia turtur*), cuckoo (*Cuculus canorus*), green woodpecker (*Picus viridis*), jay (*Garrulus glandarius*) and long-tailed tit (*Aegithalos caudatus*) etc. Nightingale (*Luscinia megarhynchos*), wood warbler (*Phylloscopus sibilatrix*) and yellowhammer (*Emberiza citrinella*) live here on the periphery of their habitat requirements.

There were no significant differences between the status survey of 1992 and the survey of 1995. A slight alteration could be detected in the area closest to the road where 14 specimen of 6 species were recorded in 1992 while 7 specimen of 5 species occurred in 1995.

Evaluating autumn migration and overwintering relations, the 1994 autumn survey deserves interest: individual numbers of recorded species declined with the decreasing distance as approaching the road. Only 7 specimen of 5 species (comparing to the total bird checklist of 17) were recorded in the autumn, and 46 individuals of 9 species were recorded in the winter survey.

Quantitative analysis of avifauna, Tétény Plateau sample site

Skylark (*Alauda arvensis)* was the dominant breeding species on the Tétény Plateau sample site when the status survey was made in 1992. Between the skylark territories the crested lark (*Galerida cristata*) territories are inserted along the cart-tracks. Wheatear (*Oenanthe oenanthe*), linnet (*Carduelis cannabina*) and red-backed shrike (*Lanius collurio*) live in the ditches and shrubs.

There were no great differences between the samples of 1992 and 1995 concerning either the breeding or the migrating bird species. The one third of the 3 hectares sampling site situated closest to the road rather changed: from an edge of a steppe slope to a ruderal, later to a recultivated area just at the side of the road. The other two third of the sample site – on higher elevations of the hillside and on the upland 15–20 metres above the road – remained intact. The grassland grazed by sheep provides suitable habitat for the former grassland bird community after the construction as well.

Vertebrates run over on the road surface

The highway as mortality factor is significant for vertebrate populations living in habitats along the road. Primarily mammals fall victim to the traffic owing to their nocturnal activity and to the sparse (insufficiently frightful) night traffic. Beside small rodents (*Micromys minutus, Clethrionomys glareolus*) greater mammals as hare (*Lepus europaeus*), beech marten (*Martes foina*) or even stray domestic dogs are also run over.

Birds represent a relatively low ratio of run over animals, only 2 specimen were recorded in the road section 0–14 km, and one more (a buzzard, *Buteo buteo*) at the 17th km. The two victims belonged to the most frequently occurring species close to the road: pigeon (*Columba livia* f. *domestica*) and house sparrow (*Passer domesticus)*. Possible explanations of the low ratio of birds among vertebrates in accident are described in the following.

The four-lane wide road surface does not attract birds landing for feeding. Species and individual number of birds is insignificant both on and nearby the road. The traffic of the day (daylight) is so dense, fast and dynamic that birds have no time and space for landing on the roadside.

However, the crested lark (*Galerida cristata*) living frequently on the roadside adapted very well to the traffic and is able to evade even from faster vehicles by its mobility.

Summary

The completed five-year long monitoring study intended to follow the environmental impacts of the construction and operation of a motorway. It may serve as a useful basis for planning future monitoring activities. The study sites can be considered “conflict areas" in terms of nature protection (the site at Diósd was destroyed totally, the other site at Törökbálint suffered diffuse damage in a 20–30 metres wide zone). Similarly, both sides of the highway in a 20–50 metres zone requires specific interest and investigation in the future, and should be considered as conflict zone both considering botany and zoology.

5.3.3. Corridor function (The role of linear infrastructures in the invasion of species)

Invasion is the process by which a newly introduced foreign species, but sometimes a native species, starts sudden expansion and temporarily or steadily restructures living communities. Primary reasons of invasions were formerly the climatic changes. In the past decades the traffic and transportation had significantly accelerated these processes. Decrease of biodiversity was proven in every case.

Direct background of the phenomenon is the growing effectivity of propagule spreading. Propagules (seeds, eggs, vegetative reproduction organs as gemmules, root and rhizome pieces) utilize the possibilities of linear establishments and gain such a high spreading potential which was never seen before.

An important factor is the stability of the receiver ecosystems. In general, the pioneer associations (grassy or nude banks, road shoulders, verges, construction areas) are more vulnerable to invasion while fragmented semi-natural habitats resist invasion to a certain extent – depending on their size and type.

Invasion was only slightly studied in Hungary, however, was early noticed. The first data provider was Sándor Polgár who detected some dozen North American invasive species in Győr–Sopron county after an American–Hungarian co-operative had increased its railway transportation volume. The most dangerous allergen species, the ambrosia (*Ambrosia elatior*) has also reached Hungary through this gate. Early spreading of ambrosia was reported – primarily from the Transdanubian region – by Ádám Boros and the species had gradually occupied the whole country. The western invasion is proven in this case.

No other publications were found about invasion, however, several manuscripts do exist. One of the most striking phenomenon was the mass damage of city road trees between 1996 and 1999 (by horse chestnut leaf-mining moth *Cameraria ochridella* and by platan lace bug *Corytucha ciliata*). Localization of the damaged trees showed direct connection to linear establishments.

Semi-natural vegetation may survive or can be reconstructed on the banks of old (80–150 years old) railways, roads and channels. Invasion barely occurs here, however, these habitats have a significant relict preservation function. The stabilizing and preserving functions were also documented in the Kiskunság National Park (3rd district, alkali fields at Fülöpszállás near Szabadszállás, Németh 1986–89).

Special studies were concerned on road verge vegetation within the frame of M0 expressway Biomonitoring Program (see case study no. 1). The propagule spreading function of the shoulder of the newly established road was witnessed primarily in the case of transported cereal species (wheat, barley, rape) and secondarily in the case of some native species requiring special habitat (*Vulpia bromoides, Puccinellia distans*).

The Hungarian Botanical Society started studying the spread of adventive species only in the last 5–10 years. Within the National Biodiversity Monitoring Program, the pilot project, dealing with the spread of invasive species was launched last year. First results of this project will

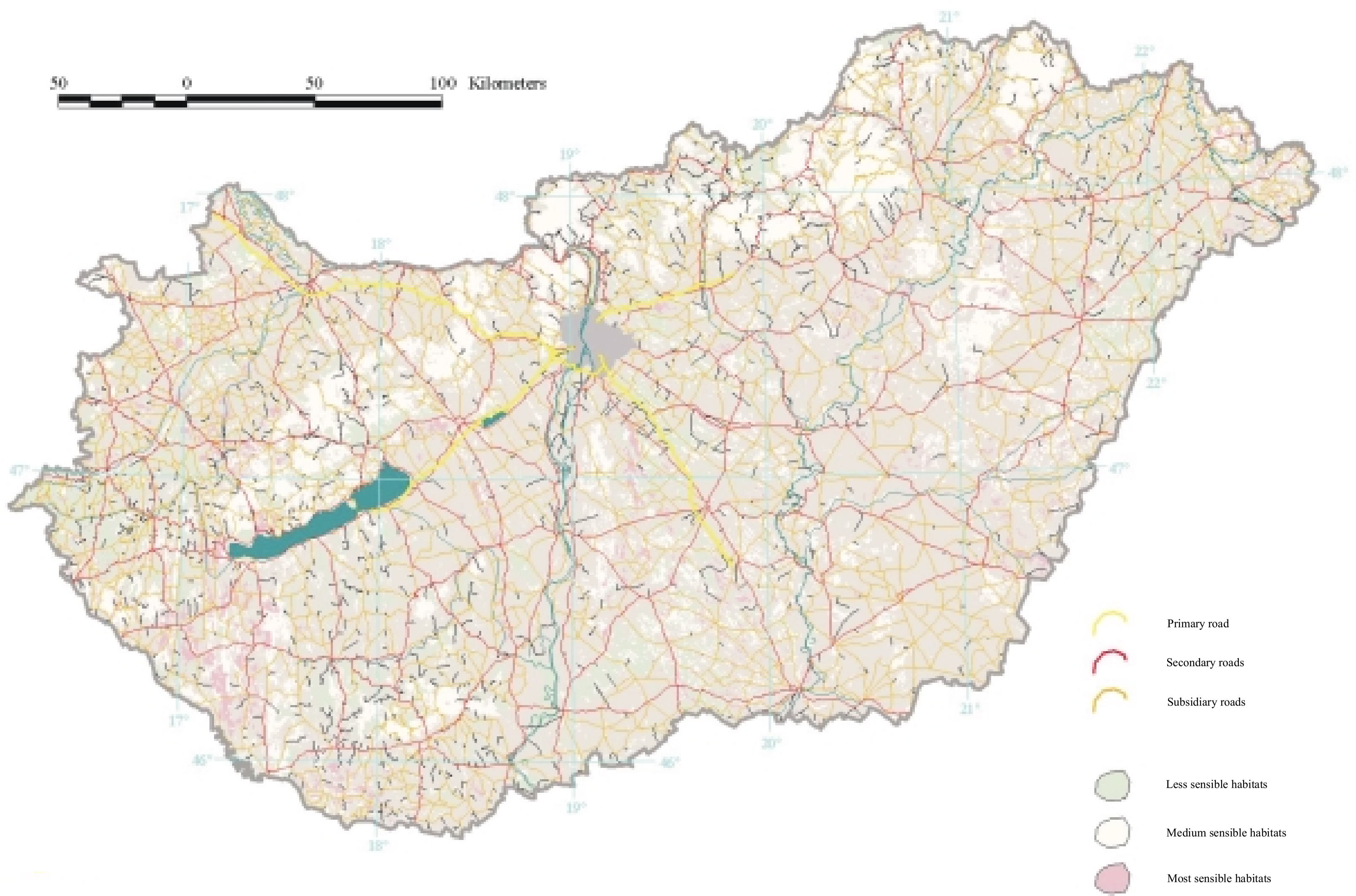


Figure 5.3.1.1. Habitat fragmentation risk and road network (map by RISSAC, data source: AGROTOPO and CORINE databases and TISNR data).

probably be utilized by nature conservation and road designer practice in about five years time, for example in the field of planning road shoulder and embankment vegetation as well as for nature friendly maintenance techniques for road verge and shoulder vegetation.

5.3.4. Fauna casualties

The data resources are available in Hungary concerning effects of traffic and transport on the fauna selected information is presented in Table 5.3.4.1.

Table 5.3.4.1. Data resources regarding animal casualties

data collected by	subjects of survey	time interval of data collection	collecting/recording method and data reliability
qualified hunters	game species, country level	continuous since 1998	annual game management report of qualified hunters (hunting associations); reliability depends on the cca. 1200 informators, can be estimated to cca. 80%
public road directorates	accidents with human casualties, country-wide	continuous	immediate data registration on computer; reliable
insurance companies	accident with loss insured, for every insured unit	irregular collection of data, by damage	record is different, depending upon companies, on damage survey forms until 1998; reliability is doubtful
National Authority for Nature Conservation, Ministry for Environment	Biodiversity Monitoring Program, 40 integrated sites all over the country, mainly on protected areas	regular surveys of taxonomical groups since 2000, surveying time frequency depends on animal or plant group and on localities	surveys by expert groups, data recorded and processed on computer in the near future; reliable
universities, research institutes, NGOs	financed from different sources, programmes dealing not/not only with fragmentation	irregular surveys, short, usually only few years long programmes	research reports are frequently made without reference study; reliability varies
Hungarian Natural History Museum	data of different programmes	continuous data registration of taxonomical groups of animals	digitalized data of reliable scientists

Invertebrates

There are roughly 42.000 animal species registered in Hungary, 99% of which are invertebrates. However, effects of transportation on a major part of the Hungarian fauna were not studied in details by any of the research groups. The single monitoring-type study was the one mentioned earlier in case study no.1, with two study sites (described as well in case study no. 2) at the 0–14 km section of the M0 expressway between 1992 and 1995.

Case study no. 2. INVERTEBRATE FAUNISTICAL STUDY OF THE M0 EXPRESSWAY, SECTION 0–14 KM

By O. Merkl

The construction of the studied section of the M0 expressway was started in the second half of 1992. The road was opened in 1995. The aim of the investigations was to identify the damages caused by the construction and operation of the studied expressway section on the natural values of the surrounding area.

Lead accumulation in diplopods

There is practically no difference in the lead content of samples from 1992 and from 1995 (0.26–5.5 g/g in 1992 and 1.3–3.9 g/g in 1995). Though standard deviation of sample 1995 was much less, it has no influence upon the fact that there was no significant change in lead accumulation in the past 3 years. It refers to (1) the insignificant amount of lead emitted by vehicles incorporated to plants, or (2) that the lead accumulation did not reach the consumers of fallen leaves until the study, or (3) the amount of lead emitted is unimportant.

Arthropod fauna of the soil surface

Analysis of the samples of pitfall traps showed that species dispersion in the inner forest was more or less uniform in both sampled years (1992 and 1995). One may conclude that there is no detectable effect of the road construction yet on the arthropod fauna of the undisturbed forest patches. In 1995 the species composition of the first trap (closest to the road) strongly differed from the further ones, because road construction and the consecutive tree felling caused drying out. The *Megaphyllum unilineatum* is the most frequent Diplopoda of xerotherm habitats and does not occur in the inner part of forests. *Harpalus distinguendus*, *H. rufipes* and *Calathus ambiguus* carabids are typical indicators of disturbance. *Amara aenea* is a characteristic species of agricultural areas and abandoned lands.

Beetles living on foliage

One of the two sample sites (see site description in case study no. 1), the Törökbálint forest became weedy (indicated also by the numerous appearance of leaf-beetles *Galeruca tanaceti* and *Galeruca pomonae*) and treetop defoliation could be detected. There was no other changes in the beetle community of the forest. However, in the other site at Diósd, the sampling site lost almost totally its former state. The vast degradation obviously affected the beetle community, e.g. the characteristic leaf-beetle species (*Cheilotoma musciformis)* of open, bare dolomite and limestone habitats could not be recorded in 1995. On the plant musk thistle (*Carduus nutans*) growing in great numbers on disturbed areas, a long-horned beetle (*Agapanthia dahli*) population lives in high abundances. The ground-beetle *Calathus cinctus* is characteristic for devastated areas under antropogenous pressure.

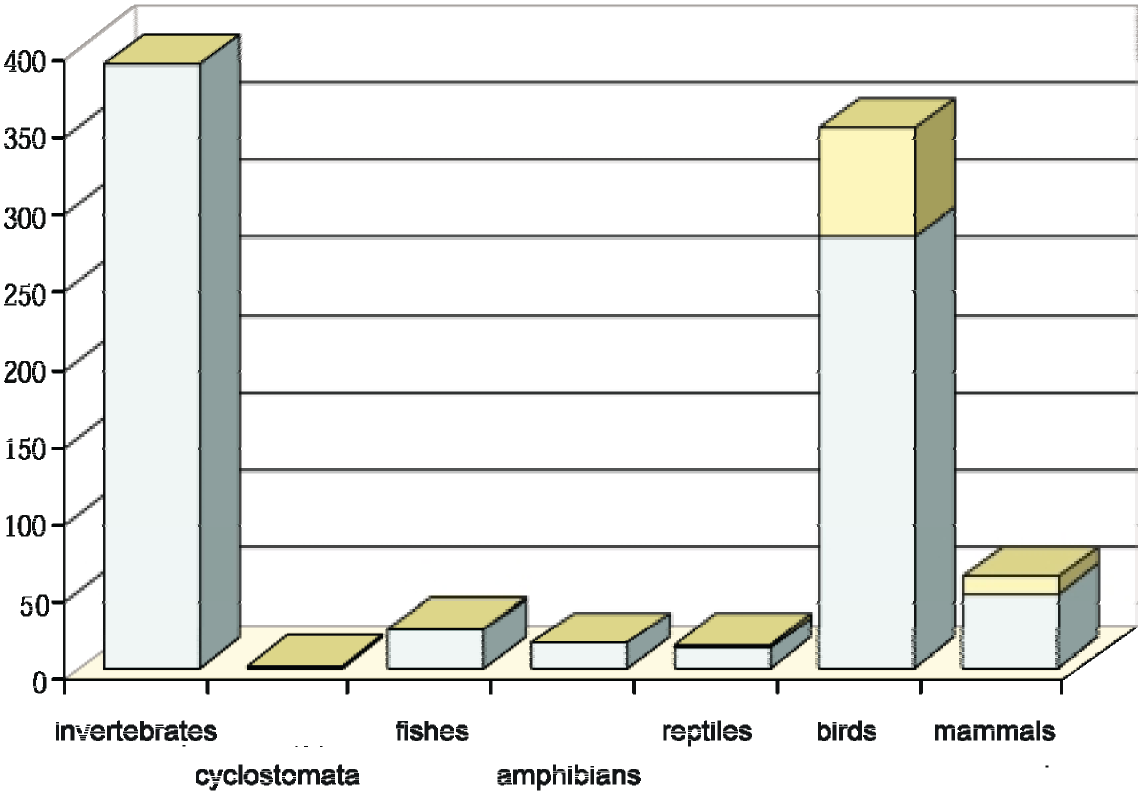


Figure 5.3.4.1. Number of protected and strictly protected animal species in Hungary (blue: protected species, yellow: strictly protected species).

Amphibians and reptiles

Vertebrate fauna of Hungary has 556 species, 475 of which are terrestrial (438 of them are protected) potentially affected by transportation (Figure 5.3.4.1.).

80–90% of vertebrate species that fall victim to cars, belong to amphibians and reptiles. The collision risk of four species belonging to amphibians and reptiles was studied at a country level by the research groups of the Institute of RISSAC and of the Saint Stephan University of Gödöllő within the frame of this COST project. Study results are shown in case study no. 3.

Case study no. 3. HABITAT VALUE AND TRAFFIC PATCH MAP

By T. Tóth, L. Pásztor and B. Bakó

Estimated/modelled distribution range map of amphibians and reptiles served as basis for the map, because UTM distribution maps of 10×10 km grid size were not sufficiently detailed and the inventory of the studied species was not complete for the country. The distribution ranges of the chosen species were estimated by creating models in the scale of 1 : 100.000.

The following presumed environmental limits and measures were used in the modelling processes:

	Yellow-bellied toad (*Bombina variegata*)	Common frog (*Rana temporaria*)	Aesculapian snake (*Elaphe longissima*)	Sand lizard (*Lacerta taurica* syn. *Podarcis t.*)
Soil type				sandy
Annual mean temperature	< 10.5 °C	< 9.5 °C	< 10 °C	
Average annual precipitation	> 650 mm	< 650 mm	> 650 mm	
Habitat	forest	forest	forest	
Relative relief	50–150 m/km	< 50 m/km	50–150 m/km	

Matrices were established for quantifying the quality (correctness) of models in which the estimated and the recorded occurrences were compared. The following table shows the precision of models of species:

Species	Uncertainty factor	Total precision(%)	Cases recorded (%)
Common frog	0.28	92	74
Yellow-bellied toad	0.21	89	69
Aesculapian snake	0.12	89	49
Sand lizard	0.11	82	63

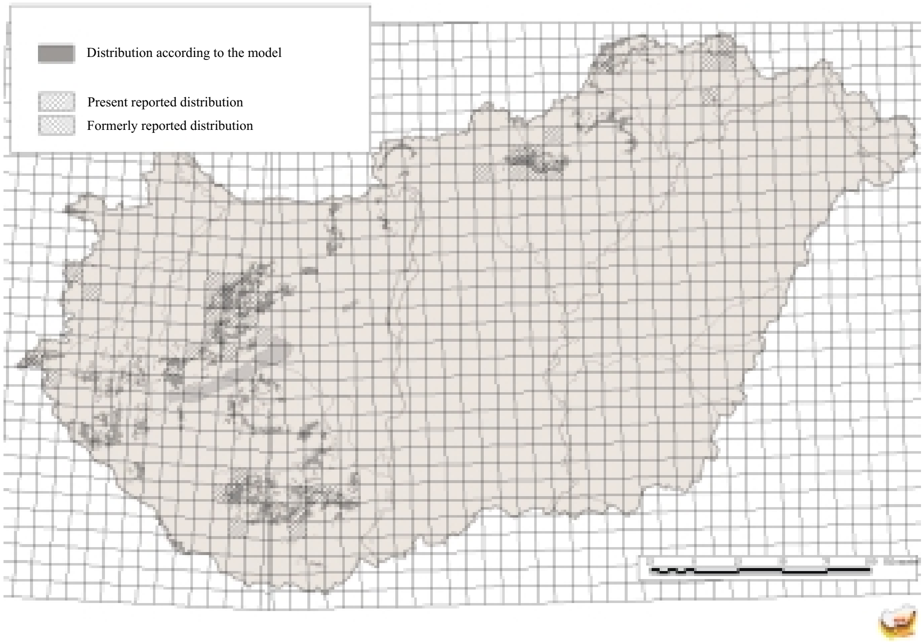
Model precision was very different for different species (Figure 5.3.4.1.). Species with an uncertainty factor below 0.1 were disregarded from the study, because their ecological modelling could not be accurate enough.

For representing traffic data on map, the traffic database of the Technical and Information Services on National Roads was used. This database was the source of the derived measure: the road density weighted by traffic density for one square km (vehicle/day × (km/km^2) which measure shows the number of cars running 1 km within the 1 km^2 grid cell a day, or the length (in km) of road sections with one vehicle/day traffic intensity within one grid cell etc.

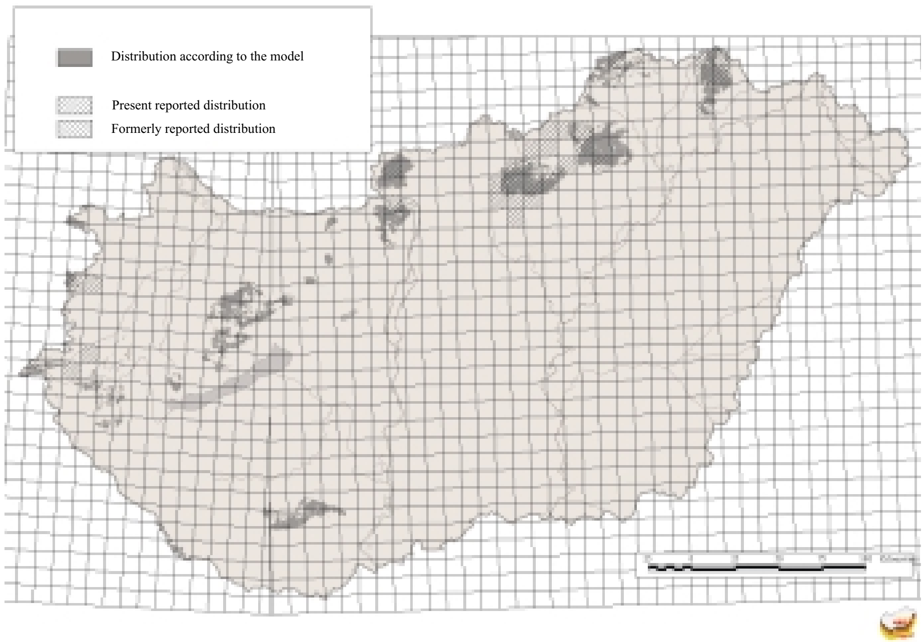
Inventory status of amphibians and reptiles are shown on inset maps. Territory of Hungary can be covered by 1060 UTM gridcells of 10×10 km. From 375 cells there are occurrence data for amphibians and reptiles, thus their inventory status is 35% for Hungary.

Summary

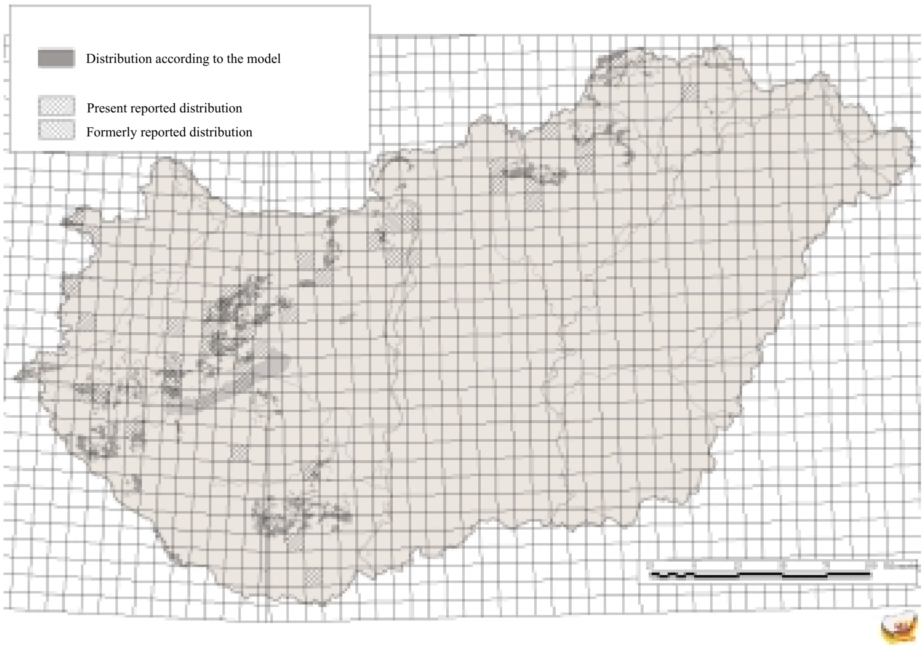
Comparison of the national habitat values and the traffic map show that the experimental methodology is applicable. However, no general conclusion can be made on the base of these four species mainly because they range is restricted more or less to the mountainous areas (see the table about their ecological requirements and the modelized distribution maps). Species with the highest collision risk (for example common toad *Bufo bufo*, agile frog *Rana dalmatina*, edible frog *Rana esculenta*) were lacking appropriate data and thus were omitted from the analysis and consequently the conflict map of this study does not show the notorious sites of running over amphibians e.g. the circle route of Lake Fertő or the Ipoly region. For the interest of the usability of maps in scale 1:100.000 as well as the accuracy of ecological modelling has to be increased. Thus the necessity of the gradual inventory of the remaining 65% cells is obvious.



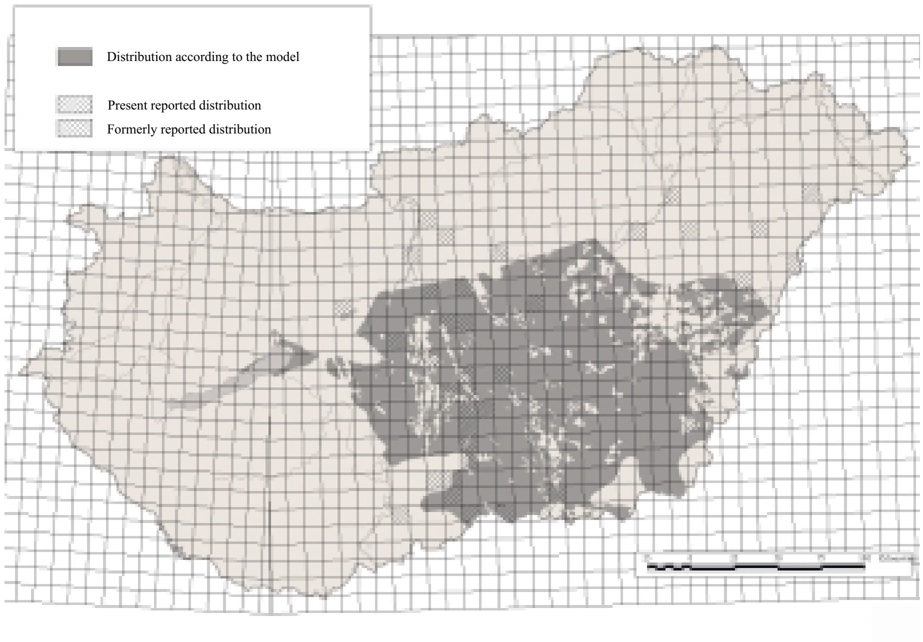
5.3.4.1a. Distribution of yellow-bellied toad



5.3.4.1.b. Distribution ofcommon frog



5.3.4.1.c. Distribution of aesculapian snake



5.3.4.1.d. Distribution of sand lizard

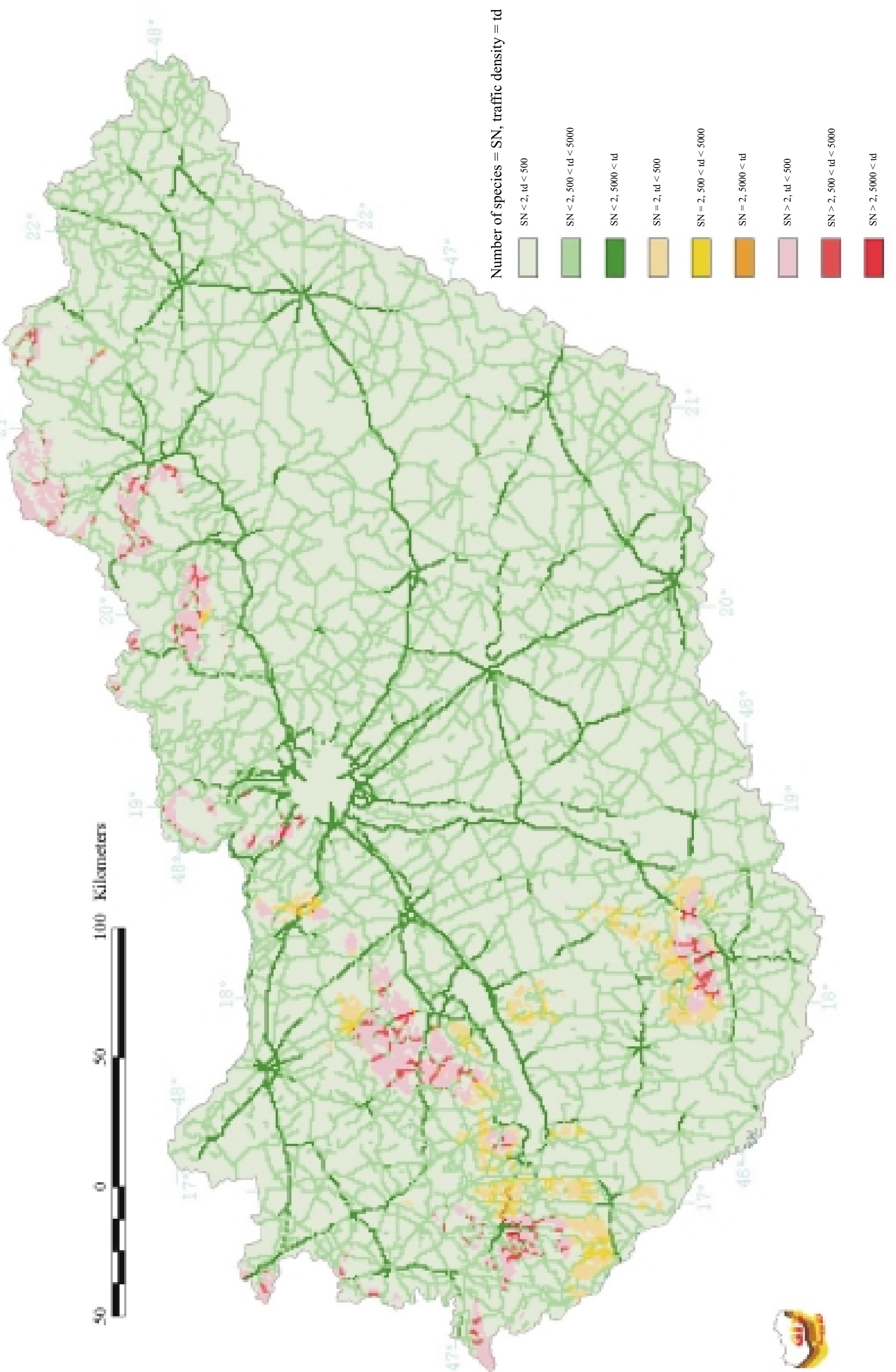


Figure 5.3.4.1. Habitat value and traffic density patch map.

Birds

The oldest protected group as well as the most numerous group of the vertebrate fauna of Hungary are birds. The statement, that road environs are suitable reproduction habitats for birds is supported by our case study no. 4 about birds fallen victim to traffic. Among victim species there are numerous species breeding on road verges and at ditch sides (*terricol* species as for example stonechat *Saxicola torquata,* whinchat *Saxicola rubetra,* crested lark *Galerida cristata*), breeding on trees of tree-lines and forests at the road (*arboricol* species as for example collared dove *Streptopelia turtur*, blackbird *Turdus merula*, red-backed shrike *Lanius collurio)* or in bushes (*fruticicol* species as for example wood pigeon *Columba palumbus*, green finch *Carduelis chloris*, chaffinch *Fringilla coelebs*, goldfinch *Carduelis carduelis*, magpie *Pica pica*). If older trees are also living in the vicinity, than hole nesting species (*dendricol* species, as for example starling *Sturnus vulgaris*, house sparrow *Passer domesticus*, tree sparrow *Passer montanus*) may fall victim to cars as well. The road surface and the close vicinity is suitable for collecting nest building materials (Schmidt 1986).

Beside providing breeding habitat, road surface and road environments have important food resource role as well. The road and its vicinity have special microclimate which may be more favourable – in some aspects – than the natural environment. Road surface warming up faster and retaining high temperature for longer time attracts arthropods (having environment dependent body temperature) and their presence offers an outstanding hunting possibility for insectivorous birds. Utilization of food resource is even better on roads with traffic because arthropods died on windscreen or on grille are more easily collected (with less energy input) than hunting for living prey, resulting in a better survival strategy. Crested lark (*Galerida cristata*) was recorded to feed frequently its young with insect bodies collected this way (Schmidt 1986).

Human activities as the application of deicing salt, trampling, or the lead emission formerly increased the presence of weed species on road verges, among them species (e.g. various *Polygonum* sp.) with seed production important for granivorous birds. Cereal seeds falling from crop transporters also offer rich food sources for them. Some birds (for example rooks) may feed on wastes thrown from cars. Certain birds of prey prefer hunting for small mammals or insects crossing roads (for example the European kestrel *Falco tinnunculus* at daylight, or the little owl *Athene noctua* at night). Finally the animal carcasses along the roads attract some bird species as common buzzard (*buteo)*, magpie, hooded crow (*Corvus corone cornix*), but there are records of white stork (*Ciconia ciconia*) feeding on run over frogs and toads as well (Onuczán 1992). Birds may warm up on road surface on cool mornings or they may bath in water collected on roads after rain showers (Schmidt 1986).

Beside the above mentioned breeding and feeding habitat functions (mostly positive roles) of roads the negative effects have to be mentioned as well. The most important is the barrier effect of roads which can be observed at fenced motorways or even at roads leading close to water bodies. Waterfowl breeding or feeding further from water bodies and thus crossing the road is necessary, may be actually restricted by intensive traffic – for example if they rear youngs moving only on the ground. Sandpipers are found most frequently in this situation but avocet (*Recurvirostra avocetta*) was also recorded as isolated by road (Kasza 1994).

Grey or asphalt surface may be misleading in foggy weather or at night and birds land on road instead of water surface. Grey heron, coot and bean goose were recorded landing onto the roads of Sopron, a city in West Hungary at the main migration route of waterfowl. Many waterfowls (among them mallard, garganey, coot, lapwing) were observed on the road surrounded by middle-aged beech forest of Brennberg valley close to Sopron (Kárpáti 1987). Their stay on the road mostly leads to their death.

Among the negative effects of roads on birds we have to emphasize the bird damages caused by vehicles. These damages may be:

- occasional ones effecting great number of birds, or
- the continuous perish caused by the permanent traffic.

An example of the occasional damage was the death of some hundreds swallows at the Danube Bend (21. July 1981). Those birds were hunting above the road in the cool weather, mainly inexperienced young swallows (Nagy 1981). In the vicinity of pheasant rearing farms the possibility of mass-collision is increasing if pheasant density is high.

Birds occupying various habitats at roads are living in continuous collision risk. Bird casualties are primary related to their feeding activity along roads.

Case study no. 4. EFFECT OF TRAFFIC AND TRANSPORTATION ON BIRDS IN HUNGARY

By S. Faragó

Introduction

A survey of bird road kills has been carried out on the basis of mainly literature data, originating from 8 road sections around Hungary.

All surveys were made in summer of different years between 1978 and 1990.

It can be stated, that on the base of the eight study transects the granivorous and the insectivorous species have the highest collision risk. Species mostly endangered are ranked as follows (percentage valkues of occasions are given): house sparrow (*Passer domesticus)* – 31.7%, swallow (*Hirundo rustica)* – 11.3%, tree sparrow (*Passer montanus*) – 10.9%, pheasant (*Phasianus colchicus*) – 9.4%, blackbird (*Turdus merula*) – 7.1%, goldfinch (*Carduelis carduelis*) – 4.7% and red-backed shrike (*Lanius collurio*) – 4.2%. There are occasional cases of unexpected species as for example the stone curlew (*Burhinus oedicnemus*) or the water rail (*Rallus aquaticus*).

Another study was made close to Budapest in 3 consecutive years for a network of roads of about 120 km. It can be concluded that dominance ranks are changing in time and the frequency of insectivorous species is decreasing. The number of casualities increased only in the case of tree sparrow, a generalist species. Beside tree sparrows house sparrow, red-backed shrike and goldfinch die most frequently along roads as the three-years average shows.

Management recommendations

Bird damages can be significantly lowered by satisfying certain conditions, namely:

- wetland areas have to be avoided by new roads,
- reconsideration of planning guidelines for tree rows: increasing the planting distance from the road, planting only one side of the road (decreasing avenue cross flying),

- decreasing the amount of cereal and other agricultural product lost during transportation, thus decreasing the abundance of granivorous bird and mammal species and that of their predators,
- regular cleaning of waste and preventing littering along roads,
- systematic removal of animal cadavers as frequently as possible,
- reconstruction of attractive habitats further from the road,
- regular mowing or clipping of road verges 1–2 m wide for preventing the seed production of weeds.

Mammals

Several publications report about effects of transportation on mammals, some of them were shown in chapter 4.2. Systematic survey at a national level, however, was only made two times (in 1996 and in 1999) regarding the non-protected game species.

Hunting association territories were the reference units in both surveys thus the results reflect the collision risk of different road sections. Owing to the lack of detailed data (accidents in relation to wildlife fences etc.), no management recommendations can be derived from the studies.

One of these studies analysed the game collision data from 1995 (by the Environmental Management Institute, consigned by the Ministry of Agriculture). Area coverage was about 35% of Hungary's road network, thus the survey can be considered representative for the country. Results of the study are described below (Pallag 1996).

Strong correlations were found between collision numbers and population size in the case of roe deer and red deer. Estimated total collision number of red deer was about 450–500 (population number is 50.000 individuals) and of roe deer was about 3500–4000 (population number is 233.000 individuals) for the investigated area in 1995.

No correlation was found between population size and collision number in the case of other big game species (wild-boar, fallow deer, moufflon). Collision risk of wild-boar and moufflon is in relation with the character of the adjoining habitat along roads. Significant part of our fallow deer population lives within fenced areas (game parks etc.) thus running over a fallow deer is a rare event countrywide.

A second data analysis (of data from 1997–1998) was made at the Sopron University. Results are shown in case study no. 5.

Case study no. 5. EVALUATION OF THE GAME ROAD KILLS BASED ON STATISTICS OF 1997/1998

By A. Bidló, S. Faragó and G. Kovács

Introduction

The data of game road kills collected and summed up by local hunting associations were processed. 1030 of the total 1200 rifle clubs have sent their summed records of game collision for the seasons 97/98 and 98/99. The submitted summaries do not seem to be reliable in the case of small game (hare, pheasant) as these data varied greatly.

The following factors were also used during evaluating the data: game population number, bag sizes, road network, number of motorized vehicles, forest coverage.

Results

Almost half percent of the Hungarian red deer population dies in accidents. Analysis of red deer casualties county level, showed that number of accidents is primarily the function of population size, or the forest coverage, that is close correlation with population size. No relation was found between deer casualty number and the length of roads or traffic intensity.

Fallow deers scarcely appeared in collision statistics, about 0.1% of the country population was involved. No statistical tests could be processed owing to the very low cases. However, on the base of the reports the relation between collision number and bag size seems to be stronger than that of the population size.

Roe deers in accidents accounted for almost 1% of the Hungarian population. Factors affecting casualty numbers are different for bucks from that of does and fawns. Its reason is their different behaviour. Ratio of bucks, does and fawns was more or less similar to the sex and age distribution of the total population.

Moufflon was reported most rarely among big game species. About 0.5% of the total population fell victim to traffic during the studied time period. The law risk can be explained by the low density and by the behaviour of this species.

Run over wild-boars account for 0.4% of the Hungarian population. No relation was found among population size and roadside mortality of boars and piglets, nor between forestry cover and roadside mortality.

Summary

Counties were possible to distinguish on the base of the data received. The most important factor affecting collision risk was the population density in most species – as it was expected.

5.3.5. Barrier effects

The following case study demonstrating the barrier effects of linear infrastructures was supported by the present COST project.

Case study no. 6. CONFLICTS BETWEEN TRANSPORTATION INFRASTRUCTURE AND ECOLOGICAL CORRIDORS IN FOREST ECOSYSTEMS

By D. Bartha, A. Bidló and G. Kovács

Introduction

For the purpose of investigating the effects of public roads on forest ecosystems the Vitnyéd section of the main road No. 85. (from Győr to Sopron) was designed. The road is open for decades. There is a forest on the northern side of the road with a typical of the mixed oak community (Turkey oak and robur, *Quercetum robori-cerris*) of the Little Hungarian Plain. Three forest stands have been selected along the road:

- old forest stand of the northern side,
- young forest stand of the northern side, adjacent to the former forest,
- similarly young forest stand of the southern side of the road opposite to the former one.

Results

No great damages of the habitats could be found along the road. No lead accumulation of the vegetation was measured at this site, which effect was often reported in publications.

Botanical investigations supported the significant barrier effect of the road in the case species with animal transferred propagules. The proportion of fruits and seeds crossing intestinal tract (endozoochor), transported on body surface (epizoochor) and carried by ants (myrmekochor) is much lower on the other side of the road than in the northern side (Figure 5.3.5.1.). Ratio of self transferred species is also lower there. However, the road is a weak barrier for wind spread species. It is worth noting, that the major part of our weeds are wind-spread (anemochor) species.

Wind spread (A, anemochor) and man-transported (At, antropochor) species are most abundant in forest belt close to the road. However, the more sensible ant-carried (M) and epizoochor (Ep) species occur here in a much lower abundance than in forest parts farther from the road.

Proportion of species indicating naturality is more or less the same in the old and in the adjacent young stand, thus there is no barrier for the spread of these species (Figure 5.3.5.2). However, the site on the other side (south) side of the road is poor in natural species (community constituant and accidental species) demonstrating the barrier effects of the road for this species group. The parallel increase of species indicating degradation (weeds, cultivated, alian, disturbance tolerant species) was observed at this site.

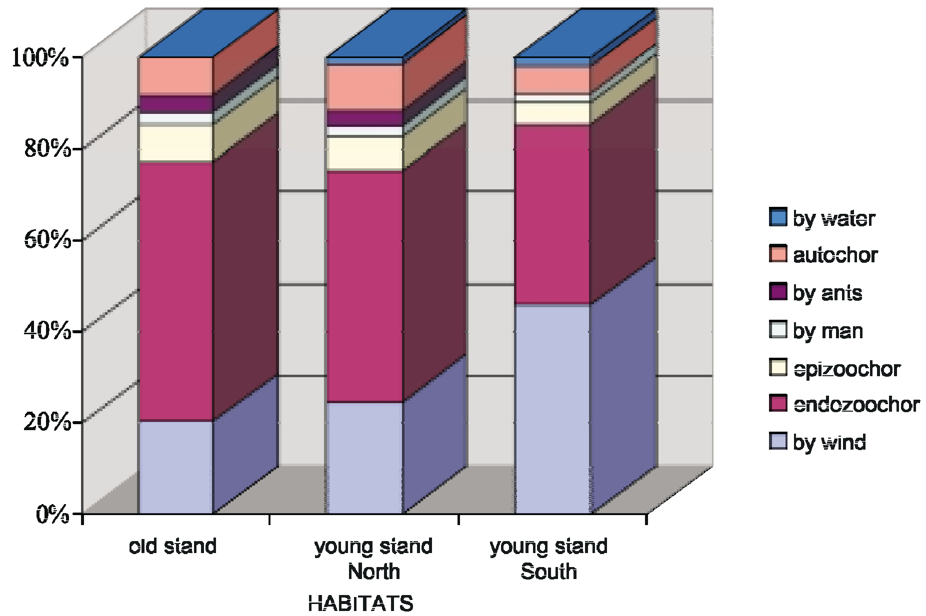


Figure 5.3.5.1. Types of seed propagation of the three selected stands

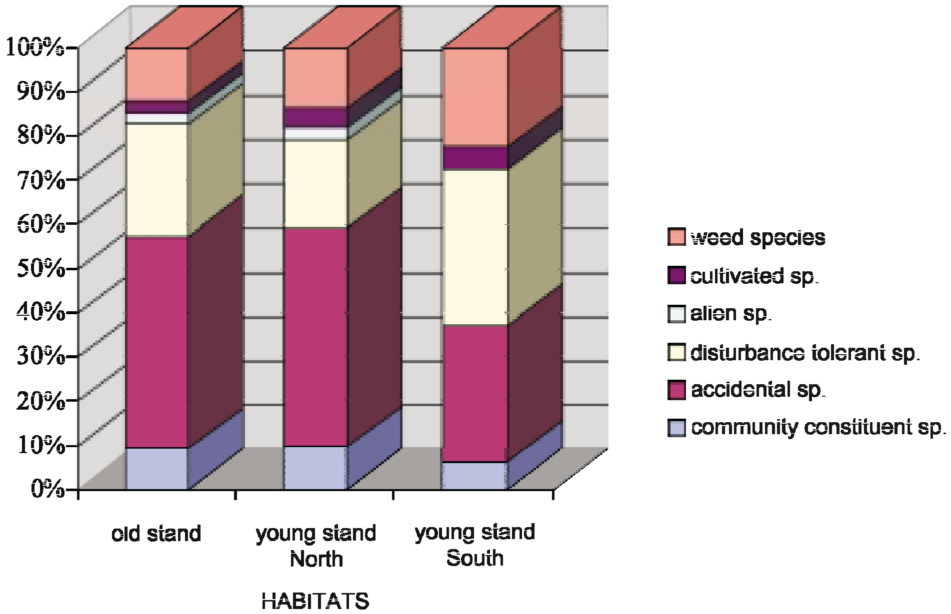


Figure 5.3.5.2. Nature conservation category values (Simon 1992) of the three stands

There is a gradient of the degrading effect of the road as a function of distance from the road. Only two-third of the characteristic secondary species of associations can be found in the forest belt close to the road, while the ratio of weed species is three times greater than in the forest parts farther from the road.

Also owing to the edge effect, shrub species are growing in a higher ratio in the forest belt close to the road. The abundance of annual and biennial species that are ready to occupy devastated areas, is greater here whereas the ratio of perennial herbs (mainly hemicryptophites) is higher farther from the road. The greater habitat disturbance close to the road is indicated by these results as well.

5.3.6. Overview of environmental bottlenecks

Conflict situations in habitat fragmentation – an overview

Habitat fragmentation conflict maps

Roads, pipelines, cables, channel and allies, altogether the linear infrastructural establishments may cause conflicts in many ways which conflicts threaten the survival of species and habitats of outstanding importance (rare or protected ones). As by our definition, habitat fragmentation conflict maps show the conflict sites and situations between linear infrastructure and different habitats. Consequently these maps are made of two different data type. Factors inducing habitat fragmentation are the ones, species and habitats threatened by fragmentation are the others (see Chapter 4.2.). The factors inducing habitat fragmentation, among them road position, traffic intensity, physical shape of road network and others are found on topographical maps, road maps and traffic maps. The occurrence data of species and habitats threatened by fragmentation can be found on protected area maps, and distribution maps. Conflict seriousness can be evaluated only by examining them simultaneously.

Two approaches (thus two investigation methods) were chosen for this purpose in Hungary:

We investigated the movement behaviour and migration data of amphibians and reptiles. Results are shown on Figure 5.3.4.1. **National habitat value and traffic density patch map** (see case study no. 3). The following databases were used for compiling the map:

- Reptile and amphibian distribution maps in UTM grid, cells of 10×10 km. (source: Oak Nature Conservation Society, Gödöllő),
- Corine Land Cover database (source: Ministry for Environment),

On the other side, we defined the fragmentation susceptibility category of habitats together with the state of vegetation and the role of habitat in the preservation of animals of outstanding importance (e.g. protected species). We demonstrate this method on Figure 5.3.6.1. **"Fragmentation conflict map".** Data sources were:

- Corine Land Cover,
- Agro-topographical database (Environment and Landscape Management Institute of the St. Stephen University, Gödöllő),
- Forestry management maps for areas adjoining to settlements (University of Sopron),
- Estimated actual habitat map of the Hungarian grasslands (Ecological and Botanical Research Institute of the Hungarian Academy of Science and BirdLife Hungary),
- Traffic density (Technical and Information Services on National Roads of the Ministry of Transport, Communications and Water Management).

The first step of map design procedure was the completion of the grassland actual habitat map with forest information. The forestry management maps were then collated with the advanced grassland map with the help of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences ("Estimated actual habitat map of Hungary" Figure 5.3.6.2.).

Fragmentation parameters of the are discussed in chapter 5.3.1. and Table 5.3.1.

On the base of susceptibility classes of Table 5.3.1, the following susceptibility rank was created for the habitat categories:

Habitat type	Susceptibility
Man made (built-up, ploughland etc.)	0
Less sensible	1
Medium sensible	2
Very sensible	3

The enclosed fragmentation conflict map of Hungary shows the importance of conflict in 1×1 km grid cells (map 5.3.6.1.). A cell of this map indicating less susceptible habitat means that mean susceptibility was below <1.5, a cell indicating medium susceptible habitat means an average susceptibility between 1.5 and 2.5, while very susceptible cells means an average susceptibility >2.5.

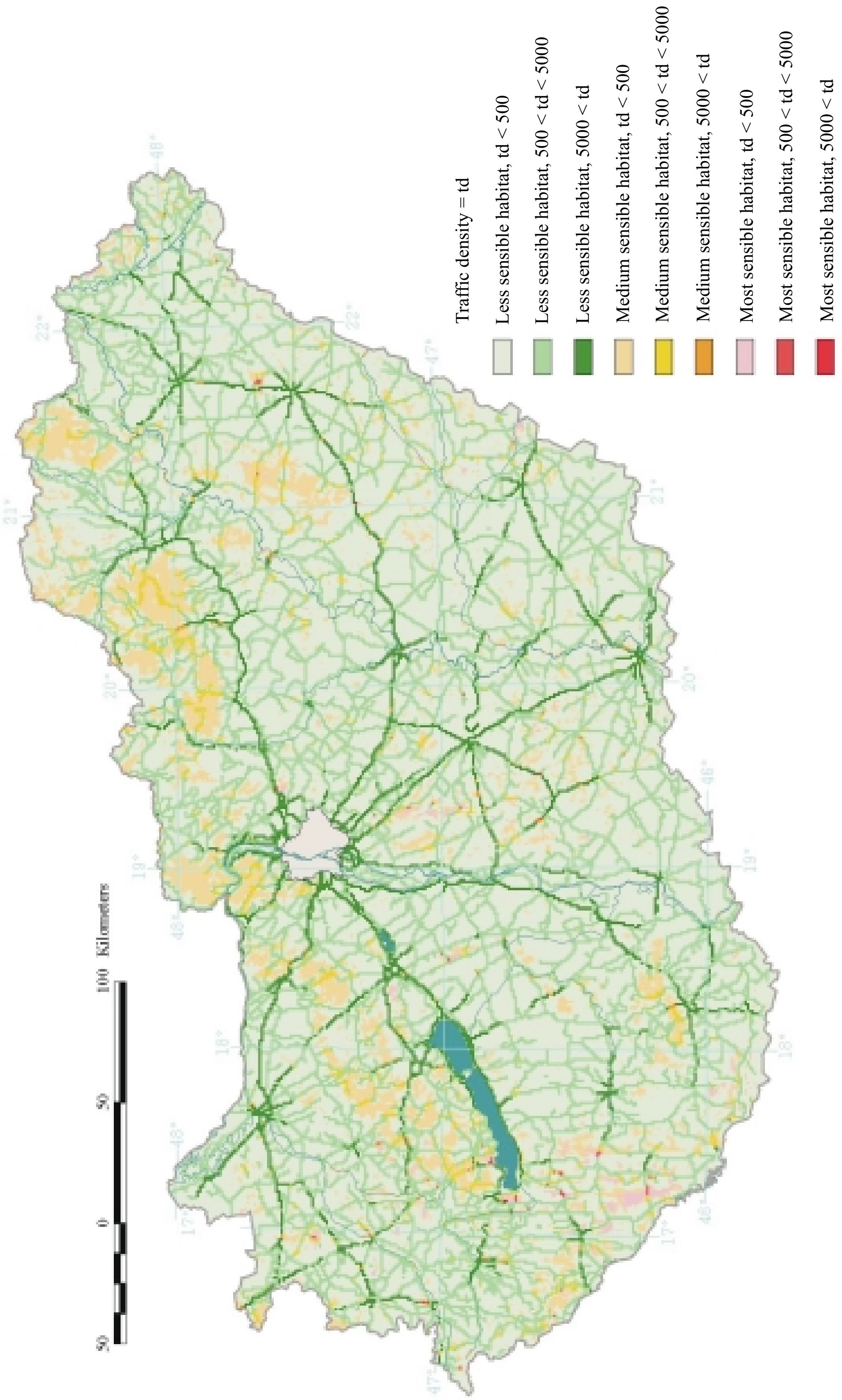


Figure 5.3.6.1. Habitat fragmentation conflict map.

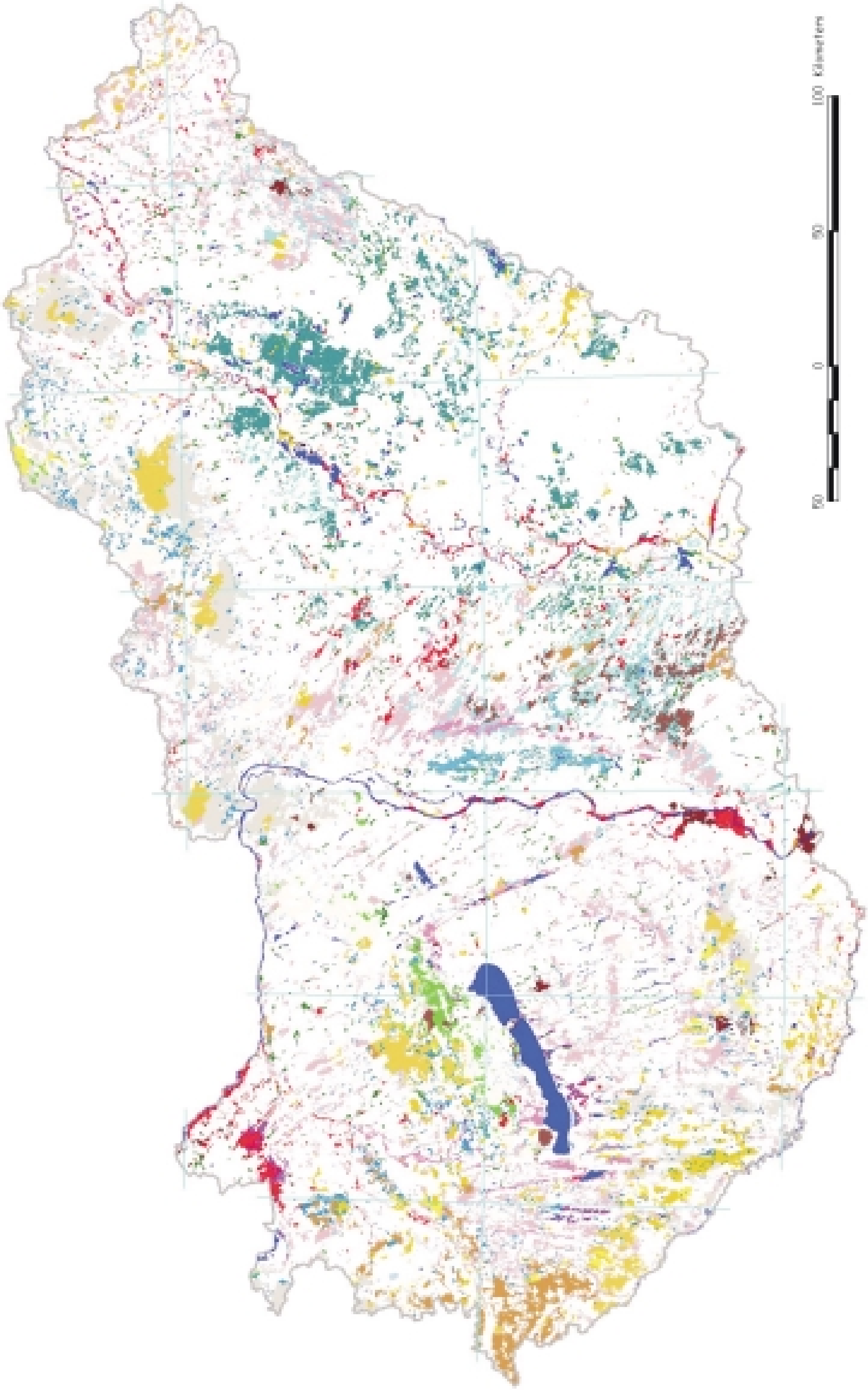


Figure 5.3.6.2. Estimated actual habitats of Hungary.

Legend for Figure 5.3.6.2.

The reliability of the two conflict maps will have to be checked in the future by field surveys. Maps will need to be revised as necessary. These conflict maps have to be used exclusively for planning tasks at a regional level. Detailed wildlife protection studies have to be made at the level of study plans or realisation plans.

5.4. Summary

Relatively few researches dealt with habitat fragmentation effects of linear infrastructures – among them of roads – in Hungary. Their results show significant differences between roads depending on their size and traffic intensity. The effects of narrow (paved) roads with little traffic is insignificant if compared with motorways or expressways the fragmentation effect of which is really strong. Botanical investigations and demonstrated that wider roads do not (or only slightly) alter the vegetation further from the road but do hinder the spread of propagules. This effect leads to a poorer vegetation in the long-run. Roads seem to be more important in the context of the spread of the invasive weed species and other disturbation tolerant species which all utilise roads for invading new habitats.

Environmental effects are more complex in the case of animals. Contrary to the expectations, significant lead accumulation was rarely found in animals (and plants) living along roads. However, segregation is well demonstrated in certain animal groups (mainly in amphibians) where road kill of animals is so high, that it surely affects population dynamics and demography. Fenced motorways similarly segregate big game populations. We have less knowledge about insects but the fact that wider roads distract several insects (even if they fly well) is well known and thus roads hamper the movement of these species.

Comparing to Western Europe, establishments to support animals to cross roads (frog tunnels, game bridges) have only been built during the part 10–15 years in relation to the development of the motorway network. The study of animal passes showed that animals mainly do use them and that certain modifications are necessary in their design in the future.

Chapter 6. Traffic safety in relation to animal casualties

Altogether 10.340 personal injury accidents happened in 1998 according to police registry (table 6.1.). Road Offices record only personal injury accidents (estimation for total accident number is about tenfold), data of animal are not recorded. Our database made of rifle club reports can not be considered as complete (see Case study no. 5). A study result – part of the research programme of the Technical and Information Services on National Roads – demonstrated that among 1303 road animal casualities in 1997 and 1998, 692 affected animals (i.e. greater mammals in this case) at outskirts of settlements (Vlaszák 1999). A part of them are dog or cat injuries, and consequently does not belong to casualities originated from conflicts between linear infrastructures and ecological networks.

Table 6.1. Personal injury accidents on national roads, 1976–1998.

Road category	Accident numbers							
	1976	1980	1985	1990	1995	1996	1997	1998
Motorway	100	68	138	226	315	320	290	376
Expressway	84	51	32	100	62	56	37	37
Primary road	2370	2115	2083	3455	2277	1914	1931	1984
Secondary road	339	3218	3549	4969	3124	2930	3123	3279
Main network	5893	5467	5802	8750	5778	5220	5381	5676
Side network	4553	4730	5258	6881	4353	3993	4167	4664
Sum	10446	10197	11060	15631	10131	9213	9548	10340

Source: Main data of roads, Ministry of Transport, Communications and Water Management, 1998

Studies on the involvement of game animals in car accidents estimate game collisions of about 4–5 thousand cases a year (Pallag 1996). Smaller vertebrates (birds, small game species, amphibians) can certainly also cause accidents, the dimension of which is estimated to exceed that of big games. About 4–5% of personal injury accidents is attributed to vertebrate animal road kills. This means about 400–500 cases yearly, a number high enough to be worth considering from human safety point of view.

The intension of saving human life appears in the 55/96 Act of Protecting Game Animals, Wildlife Management and Hunting as well. The Fifth chapter of the law states that damage caused by game animal is to be compensated, among them the damage of running over a game animal on road if the accident is directly caused by hunting or by a badly designed wildlife management (e.g. a feeder placed too close to the road, closer than 100 m). Obviously the hunter is maximally interested in conflict resolution between game animals and road network. This interest is especially important for economic aspects if we consider the significance of hunting incomes for the country. The income in 1998 of the sector was 0.67 billion HUF (Wildlife Management Database, 1999). Trophy quality of the Hungarian red deer and roe deer population is in the first–second place in Europe.

After enacting the law, the hunting right holders recorded and submitted data (within their annual wildlife management report) first in 1998 about game animal damages caused by traffic. Relations between big game populations and road kill numbers are demonstrated in Table 6.2.

Table 6.2. Population size and road kills for selected game for 1995 and 1998.

Game species	Estimated population size		Shot		Death other than of shot		Estimated collision numbers	
	1995	1998	1995	1998	1995	1998	1995	1998
Red deer	50.063	74.053	21.825	20.105	1755	1548	257	361
Roe deer	233.367	269.060	37.890*	37.894*	7176	6977	1566	2040
Wild-boar	39.389	65.621	34.979	48.481	–	2278	163	220

* Note that data are by admission. Considering population size and demography variables of roe deer the above data are underestimated.

15% of natural death (other than shot) of red deer was actually car accident in 1995, and collision risk increased up to 23% until 1998. The trend is similar for roe deer (from 20% to 30%). The increasing collision risk is certainly the result of motorisation.

Future analysis of accident statistics is extremely important regarding wildlife protecting measures. We can not disregard the result of the case study no. 7 about the efficiency of game passes, namely that roe deer kills still happen, however, M1 Motorway is supplied with wildlife (red deer) fence. While emphasizing the big game habitat segregation effect of wildlife fences the further study of wildlife protection measures is recommended.

Chapter 7. Compensation measures to reduce effects

7.1. Introduction

Environmental impact studies are obligatory in case of a number of investment types since 1. January 1985 in Hungary. The EEC Council Directive No. 85/337/ EEC was released in the same year on assessing the environmental aspects of certain public and private establishments. The Council Directive recommends the harmonisation of content requirements of Environmental Impact Assessments (EIA).

Aims of EIA are to define, to estimate and to evaluate all expected significant environmental effects of the planned activity and consecutively to influence decision making in the realisation process. EIA has usually preparatory and detailed investigation phases which are followed by environmental audit as necessary.

Since the EIA regulation, road designers became increasingly involved in planning preservation measures. More and more wildlife managers (known to be mostly familiar with game populations of a given area) were included into the planning processes. The EIA decree forced designers to elaborate routes with the least conflict and to collaborate actively with the experts of nature conservation administration during the planning phase. The following chapters deal with possibilities of decreasing/mitigating the nature damaging and habitat fragmentation effects of linear networks.

7.2. Possibilities of avoiding habitat fragmentation

First of all distinction between the existing and the planned linear infrastructures regarding habitat fragmentation is necessary. In the case of existing infrastructures the measures to be taken have only moderating role (for example the plantations to raise amenity value or the amphibian tunnels), although the environmental law obliges effective mitigation measures of environmental damages in the case of existing establishments as well. Paragraph 73. states that: for the purpose of revealing and recognising the environmental effects of a given activity and of suitably controlling the conformity to environmental requirements, an environmental impact audit has to be made. However, practice is different in the area of linear infrastructural establishments. The competent authority (here the competent environmental directorate) may oblige investors to audit activities in case of company ownership change or a great investment presumably affecting at least a microregion with environmental pollution (air, water or soil), but no such example is known for roads.

Preventing fragmentation in the planning administration

Interests of preventing fragmentation effects of roads or linear infrastructures in general can be asserted in different planning phases and levels. Prescribed recommendations of regional plans can be realised differently on the different levels of the planning hierarchy.

The Regional Planning Framework of Hungary (OTT) deals with central administrative (governmental) tasks. Regional policy plans of priority regions (national parks, some protected landscapes, Balaton recreation area and others) are partly belonging to OTT and partly to county plans. Beside national provisions county plans contain regional tasks as well.

Regulations of regional policy plans are finally defined and refined in the local policy plans of settlements. Greater investments are obliged to produce EIAs.

Primary purpose of making a **preliminary environmental impact assessment** is to register, to compare and to assess the environmental impacts of the different route options and technological versions as well as laying the foundations of a detailed environmental impact study.

The **detailed environmental impact study** (EIS) describes the present and forecasted state of the environment with and without the planned investment in relation to its activities. The detailed EIS gives recommendations for mitigating or preventing expected environmental damages as well as for the controlling/monitoring methodology of the investment operation and its effect after abandonment.

The method of searching for corridors, poor in conflicts

The most effective measure to avoid habitat fragmentation effect of new linear infrastructures is selecting the best route. The plans of the past 10–15 years have resulted in numerous successful examples of this strategy.

Following an example of Germany the digitized planning model of conflict-poor corridor was introduced in the beginning of the eighties, during the planning phase of the peripheric highway of Budapest (M0 expressway). The methodology of this planning model rests upon the estimation of sensitivity of land cover patches in relation to a wide range of environmental constraints. A 2–6 km wide transect including the planned route is analysed from this respect. A synthesis of sensitivity estimations is the next task for the investigated environmental effects. Finally, the route is defined by planners to avoid the most sensitive areas. Beside the above mentioned peripheric highway of the capital, this methodology was used in other great planning tasks as for example the M2 expressway, the expressway connecting the M0 expressway and M3 motorway, the M6 motorway section from Dunaújváros to the southern country border (Figure 7.2.1.).

Transferring/transplanting populations of protected species

It can be stated, that transplantations of protected plants raises numerous problems and is likely to fail. Transplantations are to be applied only in the last resort. Though protected plant species of Hungary can easily be maintained in gardens, the establishment/reconstruction of new populations in the field is seldom successful. Instead of attempting species transplantation, its habitat should be preserved.

Translocating a biotop

Translocating an association has a better chance of success. However, this solution is rather expensive. There are several successful Western European examples for translocation, and there is one Hungarian example as well from 1998. A swamp meadow of high value was threatened by total destruction (filling up) during the enlargement of the Zalalövő railway station at the new Hungarian–Slovenian railway line. Among other protected species, the globe trollius (*Trollius europaeus*), a liliom (*Hemerocallis lilio-asphodelus*), the Siberian iris (*Iris sibirica*) and the maiden pink (*Dianthus deltoides*) occurred there. Snakeweed (*Polygonum bistorta*) was also found in great abundances (this species can be very abundant in wet meadows of Western Europe but is rare and protected in Hungary). The competent national park directorate authorised the enlargement of the station with the condition of translocating the swamp meadow together with the broad-leaved tall herbs' meadow (about 1.7 hectares altogether). A degraded meadow with smooth three-ribbed goldenrod (*Solidago gigantea*) of similar water regime to the original habitat was fortunately found in a distance of 300 m. A step-by-step accomplishment was planned by nature conservation experts. After finishing the ground preparations, vegetation was cut out in 1×1 square metres by a special sod-cutter ma-

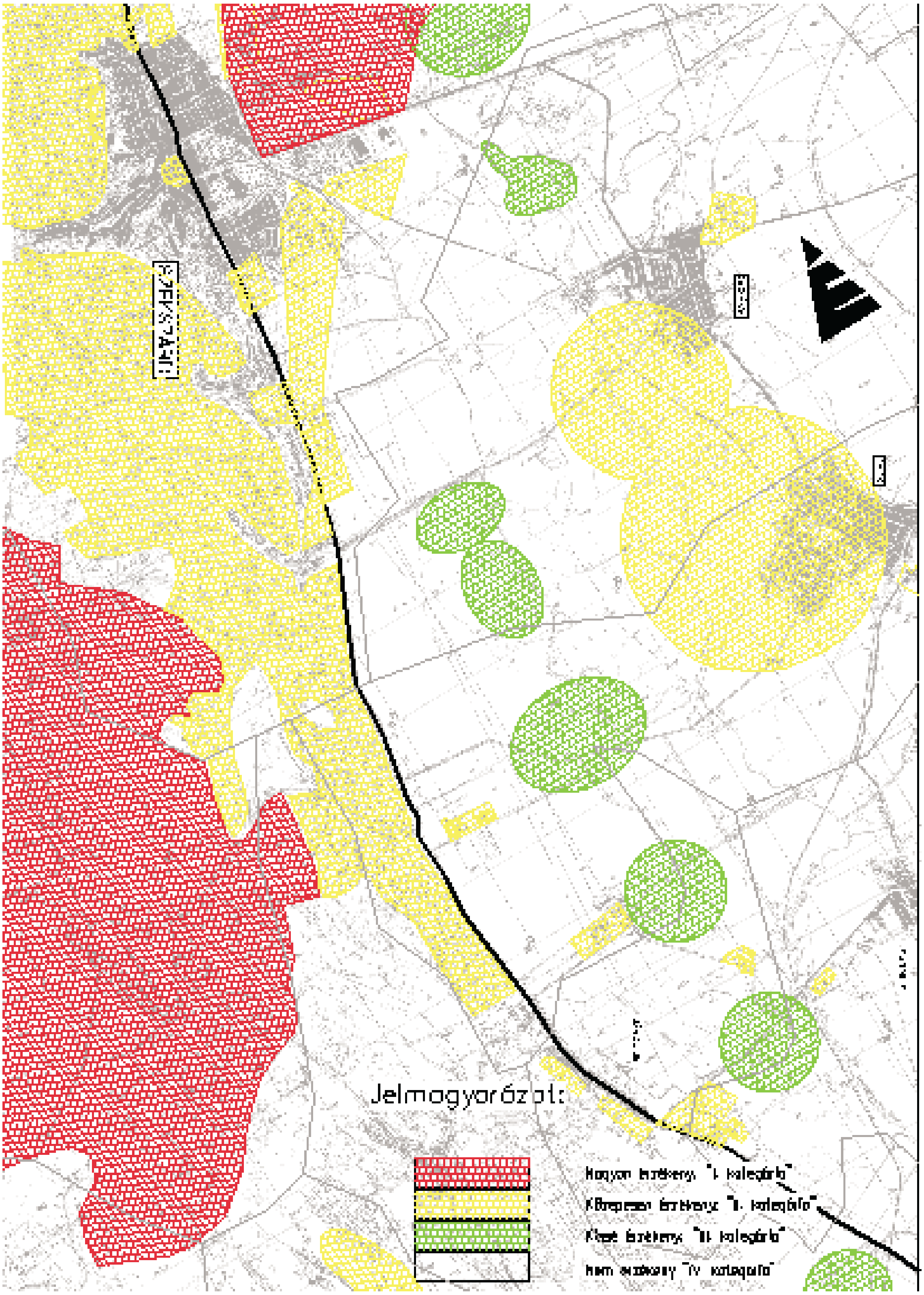


Figure 7.2.1. Selecting the conflict-poor corridor in the vicinity of Szekszárd. Legend: red = very sensitive, yellow = medium sensitive, green = less sensitive, rest = non-sensitive. Source: UNITEF, 1983.

chine and translocated. Sods were placed in their original sequence. The monitoring survey of the new habitat found in 1999 that the rare species survived in their original abundance and no significant degradation was registered.

A similar sodding preserved the very valuable drying peat-meadow with *Molinia* (an association called *Molinietum*) from degradation. Eight parallel gas pipelines of the natural gas resource in the Őrség region was planned to cut through the habitat along the Kerka creek. No other solution was found and finally the meadow was transplanted in a 20 m wide and 200 m long strip. After installing the pipelines, all sods were replaced to their original site. The method proved to be successful. The vegetation sprouted similarly to its former status and some populations of protected species even became more numerous. On the short section, where no sodding was accomplished a totally degraded weed association with tansy (*Tanacetum vulgare*) emerged.

Nature conservation principles of designing routes

During the planning process of linear infrastructural establishments the objectives of experts compiling nature conservation parts of the plan are "beside ensuring the survival of rare and endangered species, the long term preservation of the natural organisation of living communities and maintaining the complexity of biological and ecological interrelationships" (Török 1995). Ecologist must actively participate in raising public awareness of the fact, that the conservation of nature has to be asserted even beyond the fences of protected areas.

Ranked wildlife conservation aspects of route designation are as follow:

- no linear infrastructure is allowed to cross strictly protected areas,
- linear infrastructure can be designed on areas protected on national or local level with the approval of the competent nature conservation authority;
- linear infrastructure can never or only exceptionally cross the habitat or site of strictly protected species,
- the so-called "natural areas" (prepared for designation or with important natural values) have to be treated with care,
- protected habitat types ("ex lege" protection, as for example fens or alkaline habitats) deserve as much attention as possible,
- generally the most favourable solution in crossing valuable natural habitats is the one that leaves the greatest unbroken area untouched,
- ecological corridors have to be treated carefully, irrespective their continuous or "stepping stones" character.

7.3. Overview of mitigation measures

Suggestions for mitigation measures can already be part of the planning phase of road design and later that of the detailed environmental studies.

The following mitigation types were found in the practice of designing linear infrastructures:

- big game bridges, amphibian, reptile and small mammal corridors (usually tunnel),
- wildlife protecting fence,
- relocation (transplantation or transfer) of protected species, and communities (see 7.2.).

Game bridges

The greatest investments in the field of wildlife protection during road constructions are the ones made for the interest of protecting big mammal species. By far the most prominent of them are the ones under construction along the railway line connecting Hungary to Slovenia, namely a 375 metres long tunnel and two viaducts of 1400 and 200 metres long. These investments were necessary mainly for landscape protection interests. (Without these structures the railway line would require several hundreds of metres long and of some ten metres wide and tall railway beds.) Railway tunnel and viaduct are the best for nature conservation aspects (avoiding fragmentation) and at the same time they are the most expensive ones. Not surprisingly, no other structures of this great dimension were erected in the last 60 years.

A bridge over water courses or earth roads with at least 4 m wide bay serves as movement corridor for several, even for big game species. Concerning the high costs of separate level game bridges existing bridges are worth widening for a much lower budget. Main principles of designing game tunnels are listed here (valid also for bridge enlargements):

- Sizing of openings has to regard the empirical value (the so called "relative enclose") deducted from the utilization studies of game bridges. The size of the opening is dependent on the length of the bridge and the size of the species: e.g. assuming a 34 m long bridge, the dimension of openings for roe deer would be about at least 25 m² (for example cca. 4×6 m), for red deer and fallow deer about 51 m² (for example cca. 4×12 m) at minimum,
- The surface has to be slip-proof and possibly similar to the natural surfaces (avoid pattering),

Figure 7.3.1. There were no roe deer victims since 1996 along the M1 motorway probably because animals do use the game bridges.

- The inside walls of tunnels have to be painted dark up to 80 cm height and white above,
- Entrance are has to be supplied with vegetation cover and with noise and visibility reducing palisades,
- Habituation of animals to use the bridge should be achieved through feeding and the exclusion of hunting in the area.

It is important to render impossible the usage of the crosses by man and vehicle (for tunnels and bridges as well). Aspects of designing game bridges are as follows:

- The bridge structure serving as overhead bridge should be hour-glass shaped,
- Regarding dimensions, a minimum width is 8 metres for roe and wildboar and 12–35 metres for red and fallow deers is suggested,
- Surface of overhead bridge has to be covered by 50 cm of soil, and vegetation,
- Vegetation composition should harmonize with the native surrounding type,
- Habituation of animals should be achieved as for underpasses.

The construction of tunnels and bridges is of no use if the road is not protected by wildlife fences. Required density of corridors depends on game abundance and population densities and on behavioural characters of animals living in the habitats affected. The placement of corridors is to be defined together with authentic wildlife managers of the area.

Only two game bridges were constructed in Hungary, both along the sections of the M1 Motorway (147+550 and 151+750). Both ends of corridors are cornet-shaped. The 20 metres wide concrete structure is covered by earth and vegetation (Figure 7.3.1.). Parallel with the motorway a 20 m long 140 cm high stumpwood fence leads the game animals to the funnel-like ends of corridors. These log fences hide the motorway (from animals) on one side and reduce noise on the other. The log fences are continuing on the top of the bridges on both sides. The total width of bridges (20 metres) are reduced to only 5–7 metres by the covering vegeta-

Figure 7.3.2. Game bridge over M1 motorway

tion planted on the bridges. As a post-investment, the wildlife protecting fences at the bridges (in 150 metres long at all four sides) were covered by light-reflecting nets. Case study no. 7 shows the results of an experimental study about the efficiency of the big game bridges.

Case study no. 7. GAME BRIDGES OF THE M1 MOTORWAY

By G. Takács and A. Pellinger

The aim of the study of two game bridges over the M1 motorway was to:

- assess the use of the bridges by game after the opening,
- to study the status of the bridges and connecting establishments.

The study area

The area under examination lies along the M1 motorway from Győr to Hegyeshalom (section 146 and 152 at Lébény). The motorway approaches the most protected areas here (North Hanság Territory of the Fertő–Hanság National Park). In this road section seminatural vegetation of outstanding values (Fűzfa Islands and Vesszős Forest) are to be found close to the motorway.

Game population estimations show that among big game species the roe deer (*Capreolus capreolus*), the deer (*Cervus elaphus*) and the wild-boar (*Sus scrofa*) occur here, in an estimated 2250 individual numbers altogether. An estimation of hare (*Lepus europaeus*) population number based on the local hunting association was cca. 3000–3300.

Figure 7.3.3. Game bridge over M1 motorway

Figure 7.3.4. Game bridge over M1 motorway

Some game bird species are also listed in the game management inventories, as pheasant (*Phasanius colchicus*) and partridge (*Perdix perdix*) and the inventories mention the occurrence of the strictly protected great bustard (*Otis tarda*) as well.

The game bridges

Two establishments were constructed along the motorway exclusively for ensuring the movement of big game species across the road. Both ends of corridors are cornet-shaped. The 20 metres wide ferro-concrete structure is covered by soil. Parallel with the motorway (in only 20–30 meters long instead of the proposed and planned 100 meters) a maximum of 140 cm (instead of the proposed 180 cm) high stumpwood fence leads the game animals to the funnel-like ends of corridors. These log fences hide the motorway (from animals) on one side and reduce noise on the other.

The 20 m width of the bridge will be reduced to 5–7 m by the time the planted vegetation will reach mature size. Only shrub and tree species of the natural vegetation were suggested to be planted, however, the planting was implemented by other – and in most cases by alien – species. The most frequent species is pyracantha (*Pyracantha coccinea*) which follows along the log fence. Instead of the native dogberry (*Cornus sanguinea*), an ornamental shrub, the tatarian dogwood (*Cornus alba sibirica)* was planted. The common ash (*Fraxinus excelsior)* was planted to the funnel gates. Part of trees and shrubs actually planted could not cope with the summer heat and totally dried out, another part of them was dug up by wild-boar.

The common wildlife protecting fence separates neighboring areas from the motorway that continues on the game bridges as well, beside the log fence. The height of the wire fence varies with the game species expected to occur on the areas in concern: 260 cm if deer is characteristic for the area, and is only 150 cm if no deer is expected. The wire pattern is not uniform: verticular wires are 25 cm apart from each other while distance of horizontal ones ranges from 8.3 to 25.4 cm. In the beginning of operation period the drains were not correctly shunted by wirenet fences, consequently larger vertebrates could go on the road and the number of accidents increased in some places. This problem was solved (by making fence detours at drains) in the first half of the year 1997.

Those culverts with 1 meter in diameter, the opening of which was sank to 20–25 cm below the ground level, primarily ensure passing the motorway for amphibians. However, they frequently dry out during the summer drought. Other canals and tubes crossing the motorway below the ground level have wildlife protecting function as well. Their openings are to be found on the external side of the fence, thus they can serve the movement of some greater bodied species.

Results

Use of big game bridges and other wildlife protecting structures

The use of the bridges was detected since 1996.

The most frequent game tracks belong to roe deer and wild-boar. 60–70% of tracks are wild-boar tracks, 20–25% are roe deer tracks, the remaining 5–10% belong to deer, fox and other species. Unfortunately humans also started to use the game bridges even by car.

Trends in run over statistics

Number of road kills since 1996 shows a significant decline (200 cases in spring 1996 to 126 autumn 1998).

Figure 7.3.5. Red deers often use game bridges

Hares are far the most frequent victims of accidents. Considering the number of causalities, foxes and cats are the second and third in the statistics. The number of hare kills is continuously decreasing since 1996 (from 99 to 26 to the end of studied time period).

Pheasants and owls (little owl and long-eared owl) follow cats in statistics. Number of killed pheasants shows seasonal pattern. Number of runs over is usually about twice (10–15 cases) in the breeding season (first half of the year) than in the second half of the year (5–7 cases). Owl carcasses are usually rare (1–7 cases) along the studied motorway section except of 1997/1 (24 cases). Low-flying birds above motorways are in danger generally. Carcasses of formerly run animals attract buzzards and other – partly or exclusively – carrion-eating species. Number of cases increased (2 in 1996, 2 in 1997, 4 in 1998).

Roe deer was run over 9 times in 1996, 8 times in 1997, and 3 times in 1998 on the Győr–Hegyeshalom section of the motorway. The formerly high number of roe deers in accidents was the consequence of the insufficiently closed drains. After repairing fences in first half of 1997 the number of running over roe deers significantly decreased. There were no roe deer victims since 1996, probably because animals do use the bridges.

Running over wild-boars was frequent in 1996, but no case was reported from 1997 and only one occurred in 1998.

Status of wildlife protecting establishments

The technical status of game bridges seems to be good, however, the planted vegetation is not suitable. The species planted do not belong to the suggested tolerant species of the natural flora but mostly to ornamental species. Plantation was not carried out with sufficient care, the soil layer was too shallow to keep moisture, even drought tolerant species dried out. The plantation of following species is proposed: blackthorn (*Prunus spinosa*), wild rose (*Rosa canina*), field maple (*Acer campestre*).

Status of wildlife protecting wirenet fence is good on the studied. It is connected well to the bridges and tunnels (ecological tunnel, channel etc.). Poplar was planted in several rows along the motorway, the selection of the native white poplar (*Populus alba*) instead of the cultivated canada poplar (*Populus canadensis*) could have been more successful. The invasion of shrubs started with common alder (*Alnus glutinosa)*, willow (*Salix cinerea)*, black haw (*Viburnum opulus*). Game footprints, primarily wild-boar and roe-deer tracks are abundant in the close vicinity of the north side of the road.

Summary

The utilization of the established two game bridges – primarily by roe deer and wild-boar – was proved despite the insufficient vegetation. The status of wildlife protecting fence is good in general. However, vehicles do run over animals on the motorway. Victims are mainly smaller bodied mammals and birds.

Wildlife protecting fences

The function of wildlife protecting fences is two-fold: it protects man and wildlife at the same time. There is no effective standard or technical guideline for its sizing. Experiences of closed big game husbandry show that the effective fence in habitats of fallow and red deers is 260–280 cm high (optical height). In areas with other big game species (roe, wildboar, moufflon) the 160 cm height of fences is enough.

Two types of wildlife protecting fences were used along the Hungarian motorways until now. The net size of the one named SALGO-FENCE is as follows: vertical wires are 152 mm apart from each other, while distance of horizontal wires gradually increase from 83 to 254 mm (bottom to top). CYCLONE wildlife protecting fence was used along the M5 Motorway. There are several types of this product, among them those densely wired fences of which horizontal wires are 89 mm apart from each other until ten units high. The total height of the very dense net ensures the protection of small invertebrates as well.

Experiences from other motorways show that at culvert openings the fence is usually incorrectly fitted to the surface and vertebrate species do cross it. A solution can be the fitting of optical game alarm cables along ditches together with hanging loads (length of 20–30 cm) at every 5 cm and the fence has to be jointed to the concrete abutment of the culvert. This solution allows animals to use the culvert as subway.

Another solution is to continue the fence down to the bottom of the ditch. Special attention has to be paid in this case for regular cleaning of the fence during maintenance. Fixing the fence into the ground (to a 30–40 cm depth) protects against digging up (by wild-boar, fox or stray dog) and at the same time increases stability.

Fence posts are usually made of 15 cm thick preserved black locust posts. The distance of posts is usually 3 m or less. In the case of a fence of 2.80 m height the post-length should be 4.20 m 1.20 m of which will be in the ground. Side-supported posts have to be placed in every 30–50 m. Expected durability of a well maintained fence is 10–15 years.

In semi-natural habitats rich in vertebrate species a dense net (of about 1 cm cells) type of wildlife fence should be applied to avoid kills of small-mammals.

Amphibian and reptile passes – technical aspects

In the Hungarian road design practice amphibian and reptile passes (tunnels) are most frequently made of circular tubes of 1 or 1.2 m diameter (ROCLA RAP or TUBOSIDER types). The two ends are surrounded by concrete wall or stonewall. If the bridge is made of water permeable material than its bottom surface should be covered by waterproof concrete. Light shafts have to be made in the central safety zone separating the different courses of the motorway (see Figure 7.3.2.). The light shafts should have 1.20 × 1.20 m or 1.40 × 1.40 m inside diameter, and their inside surface should be covered by dense white tixotrop layer reflecting the light down to the tunnel. The length of tunnel depends on the total width of the road, usually 35.70–37.80 m. Light shafts have to be covered by a screen for safety reasons.

Animals have to be driven towards the passes. NETLON H10 net is used for this purpose along the M3 Motorway (0.55m tall, wire distribution is 6×8cm, see Figure 7.3.3). The fence is worth digging 10 cm deep into the ground for increasing stability and barrier safety. Fence posts can be 10 cm black locust posts or L 50×50×5 mm steel nailrod posts. Their distance is between 2–2.4 m, depending on ground features. A plastic-covered bracing wire increases fence stability. The optical game alarm cables (see also wildlife protecting fences) are worth using for bracing as well.

A 5 cm wide upper border, leaning to outward side (45°) can avoid climbing animals from road.

L-shaped concrete walls can also drive frogs to the tunnels (wall height should be 0.5 m). Aqueducts and small current crosses can also serve as special reptile and amphibian passes along motorways.

Case study no. 8. METHODS OF PLANNING AND BUILDING FROG-TUNNELS, BASED ON EXPERIENCE ALONG THE LAKE FERTŐ

By A. Pellinger and G. Takács

Introduction, problems

The case study demonstrates the conflict between roads and animals within the territory of a National Park (Fertő–Hanság).

Road No 8518 that connects towns near Lake Fertő with Sopron, has been decimating the amphibian populations of the region since the beginning of the 1980s when traffic increased significantly. Every autumn and spring since 1987, volunteers have built rescue systems on the most crucial road section, between the towns Fertőboz and Hidegség. The experience of this 13 years long rescue project is presented below.

Location

Lake Fertő is the westernmost steppe lake in Europe, situated at the border of the steppe-woodland zone characteristic to the Carpathian Basin. During the past 200 years two-thirds of the lake became covered by reed. In the littoral zone salt grasslands and wet meadows with seasonal puddles are found. Hundreds of thousands of amphibi-

Figure 7.3.6. Tunnel for amphibians and reptiles under the M3 motorway.

ans migrate every autumn to overwinter in the hills along the lake, while in spring migration takes place just to the opposite direction. The road around the lake dissects this migration route. Although the littoral zone of the lake is accompanied by woodlands at several places, migration is most intensive on the one km section between Fertőboz and Hidegség. The distance between the littoral zone and the mixed woodlands – sessile oak (*Quercus petraea*) with Turkey oak (*Quercus cerris*), black walnut (*Juglans nigra*), and black locust (*Robinia pseudoacacia*) – of the nearby hills is only 300 metres here. The area of the National Park is a Biosphere Reserve, and in part protected by the Ramsar Convention.

The driving – saving system

The migration of amphibians, outstandingly intensive both at the country and European level, has been observed since the 1970s. With the increase of traffic from the 1980s on, the rate of road kills increased parallel.

In 1987, based on experience in Germany, the Forest Protection Department of the University of Forestry in Sopron, the "Kaán Károly" Ecoclub of the University of Forestry, and the Sopron Group of the MME/BirdLife Hungary started building a cheap driving – saving system to moderate or cease the mass destruction. The project was supported by several volunteers, schools and nature protection organisations. In 1993 aqueducts, serving as frog-tunnels have been built.

Figure 7.3.7. Amphibian tunnel under the M3 motorway.

The method applied was the following: in spring and autumn volunteers built a nylon driving-fence of 80 cm height streched on sticks, fixed in the ground 5 cm deep, along the lake-side of the road. The fence stopped the animals from moving onto the road surface and drove them into plastic buckets previously sunk into the ground. These "traps" had to be emptied several times a day and the animals carried by manpower to the other side of the road. Two industrial roads – one from the south, the other from the north – joins the affected road section. As the driving-fence had to be interrupted at these places, the prevention of destruction could not be complete.

To further develop the method, the nylon fences were connected to the two tubular aqueducts 60 cm in diameter, lying 300 m apart at the given road section. Although the animals were found to have used both aqueducts, the use of buckets could not be eliminated because of the large distance.

With the above system destruction could be significantly moderated. However, it was not as effective as expected owing to the vulnerability of the fence and the great manpower need of the method. In 1991, the Fertő–Hanság National Park came to existence and took over the organisation of the frog saving project. Based on earlier experience, the National Park Headquarters initiated the building of a permanent driving – saving system that would solve the above problems and could ensure a safe bridge to the other side of the road. Depending on financial conditions, the system would involve special aqueducts built 50–100 m apart under the road surface, and permanent driving-fences attached to them.

Figure 7.3.8. Frog-leading wall made of concrete by the M3 motorway.

Results

The special aqueducts (frog-tunnels) built from 1993 can provide crossing routes for the animals not only in the migrating season, but throughout the whole year. The five frog-tunnels built until 1998, together with the two old aqueducts, could handle the most crucial 1000-metre section. The connecting permanent driving-fence, however, has still not been built owing to financial problems.

The special aqueducts built for migrating animals are equipped with light-shafts. Since no significant difference has been observed in the use of traditional aqueducts and frog-tunnels, light-shafts may as well be discarded.

Summary

Migrating amphibians had been run down in enormous numbers in autumn and spring at one section of the road along Lake Fertő. The frog rescue project initiated by NGOs was one of the most effective spontaneous nature conservation actions in Hungary. However, it was not effective enough in the long run. The Fertő–Hanság National Park has started building permanent driving-fences and frog-tunnels. This solution, though expensive and not yet fully accomplished, proved to be highly effective.

Figure 7.3.9. Green toads are often killed on roads.

Transferring/transplanting populations of protected species

There are some examples of transplanting protected species in Hungary, mainly by transferring them from mining areas or from areas devastated by water regulation or karstic water table reduction. An example for the second type of habitat destruction is the Tapolca Basin where a fen meadow had dried out and the last individuals of a strictly protected relict primrose (*Primula farinosa*) had been unsuccessfully transplanted to several places. The primrose transferred to the Ócsa fen had flowered for 1–2 years after transplantation but later simply disappeared. Few years after the unsuccessful transplantation efforts a small population was found in an adjacent basin to the original site. This population was also threatened by immediate drainage. By retaining water on the habitat and by habitat reconstruction the species was preserved.

Ferns (*Dryopteris cristata*) were transplanted in another experiment from its damaged habitat to the Dabas fenwood. However, individuals survived for about 10 years, they did not reproduce any more and finally died. The strictly protected Hungarian colchicum (*Colchicum hungaricum*) was transplanted in vain as well from its habitat that is to disappear due to mining. There are rare examples of successful relocations of plants, as of the protected sand iris (*Iris arenaria*). Only few stems were planted to a sandy grass at Ócsa and now it grows in surprisingly great numbers.

Translocating animals is less easy than that of plants, and in the case of invertebrates it is almost impossible. However, there are exceptionally simple relocations of animals, as for example creating a new sand wall for the protected bee-eaters (*Merops apiaster*) not far from its former breeding habitat to be mined. Translocation of the European souslik (*Citellus citellus* syn. *Spermophilus citellus*) from an airport at Pécs to some suitable places of the country was partially successful as well.

7. 4. OVERVIEW OF COMPENSATION MEASURES

Compensation – according to the sense – is the replacement of a damaged or lost habitat at another site where we attempt the reconstruction of the original natural values and functions (Török 1995). Successful compensation measures within Hungarian conditions can be expected for grassland (e.g. meadow-type) or for wetland habitats. Establishing a forest of native species and with a wide age distribution needs about 60–100 years and consequently realising environmental compensation in this field is irrelevant within our circumstances.

Planting vegetation

Planting vegetation along roads may have three objectives:

- landscape protection purposes and landscape amenity value,
- taxon specific protection purposes (to avoid cross flying of birds etc.),
- environmental protection purposes (pollution, erosion control).

Basic requirement is to consider safety aspects, namely that plants will:

- not cover traffic signs,
- not hinder road maintenance,
- optically support driving.

Positive aesthetical function of roadside plantations (of trees, shrubberies, mixed plots) can be ensured by careful planning which regards the neighbouring landscape as well (Török 1995).

Requirements of harmonic plantations

- Avoid regular, unified tree-line planting which would increase monotony,
- Adapt vegetation to the relief and landscape and plant in groups like groves,
- Older and valuable elements of vegetation are worth preserving and reconstructing (regenerating),
- Forest surfaces opened up should be closed as soon as possible,
- Apply plants of diverse appearance and of different ornamentical effect,
- A rolling surface can be well integrated with dwarf shrubs,
- Use tree groups to optically dissolve sharp and mechanical surfaces for example at overpasses,
- It is important to analyse landscape colours and to integrate them to the vegetation plans.

Consider convex and concave horizons, i.e. on outstanding areas for example at top of slopes and on embankments use low species, but do not use them in valleys or depressions.

Planting tree lines and shrubs

Tree-lines and shrubs should provide the following services:

- protect neighbouring habitats from adverse effects of traffic (noise, dust, emissions, light, motion),
- eliminate erosion effects,
- function as wind and snow barriers,
- create new habitats,
- increase flying height of birds,
- raise amenity value of the landscape thus exerting positive psychological effects on drivers.

The following aspects deserve attention during planting:

- type of the wider environment (outskirts, through sections in settlements etc.),
- exposure of road to poles,
- slope and cutting characteristics,
- microregion type,
- forecasted traffic intensity,
- soil types,
- water regime and water management of soils,
- prevailing wind direction,
- other selection aspects of species and varieties to be used (see below).

Only standard materials can be used for plantation. Tree planting is allowed in a distance of 3 metres or more from the road. Vehicles leaving wind protected settlements, structures or cuttings are in danger of sudden wind-pressure. Dangerous wind-pressure can be decreased by planting gradually thinner and thinner vegetation at well defined places. Regulations and safety measures have to be strictly followed during planting.

Guidelines for selecting species

Species recommended to plant in road verges or tree rows should have the following character:

- native or species of the native associations of the given microregion,
- ecological requirements fit to the environmental conditions of the roadside (soil, precipitation, exposure, elevation),
- high contamination and pollution tolerance,
- ability to cope with extensity, drought, and lacking care,
- important aesthetical value,
- rapid growth rate,
- appropriateness to the given landscape,
- possibly long life-span,
- host plants of pests excluded (*Acer negundo*, *Morus* spp.),
- no fruit trees, or invasive and aggressive weeds,
- market availability,
- easy propagation,
- low risk of injury in case of accidents (e.g. no thorns),
- no disturbance of traffic (by visual effect, monotony, cover, mass propagula, seeds on road surface).

Special aspects to be considered:

- tree species with suitable stem height for tree-lines,
- dense canopy species for aerodynamical protection,
- avoiding weak and fragile branch species in areas of wind and snow protection,
- colonizing species for slopes,
- species with special demands for the separation closures (tolerant to drought, salt, light, hot and dressing),
- drought tolerant species to dry sites,
- humidity tolerant species to wet sites,
- salt tolerant species to alkaline sites,

- species tolerating high water table level for lake and river banks,
- species sprouting fastly are advantageous (*Avena, Bromus*).

7.5. Maintenance aspects

6/1998 (March) Decree of the Ministry for Transport, Communications and Water Management regulates the maintenance of roads and their inherent structures.

Technical managers of roads have to ensure the conditions of safe and continuous traffic and they are obliged to maintain all offices, places, stocks, deposits, maintenance and social establishments necessary to fulfil these tasks. Road management tasks are described in the National Road Management Rules (OKKSZ) effective for the total country area. The regularity and the level of the operation and management tasks of a road depend on the service level classes defined in the National Road Management Rules.

Road maintenance tasks:

- winter defrost,
- maintaining vegetation (chemical herbicides, plant protection, pruning),
- cleaning of road pavement and engineering structures,
- restoring pavement as necessary,
- maintaining road shoulders and water drainage system,
- changing or replacing pavement signs and signals.

During the execution of these road maintenance tasks the environmental aspects should always be considered by:

- fulfilling technological guidelines,
- using materials dangerous to environment economically, within reasonable limits,
- development of operation and maintenance technologies.

One of the most fiercely discussed road maintenance activity is the winter anti-freezing and ice clearing. Snowy pavement and frosty pavement both resulting in a slippery road surface with high accident risk can be prevented or resolved by cleaning, by roughing or by spreading melting agents (de-icing salts or chemicals). The most widely used melting agent is the common salt (NaCl) and its solution. Salt adversely affects cars, pavement, engineering structures and natural environment.

Aspects of maintaining vegetation in public domain

- pest control is described in a special regulation about plant protection,
- arboreous vegetation (shrubs, tree-line, forest belt) should be maintained as ordered by special authorities,
- grass mowing should be regular and time intervals depend on service level (4 to 1 times a year),
- vegetation with protecting function but out of the territory of road management has to be maintained by the owner.

7.6. Evaluation and monitoring of the effectivity of measures

Monitoring systems along the Hungarian road network

There were **32 monitoring sites along the national road network** for monitoring the pollution effect of transportation. Monitoring carried out at these sites is in most cases based on arbitrary decisions, no standard protocol exists so far. In most cases, pollution monitoring is carried out, the first example of an integrated approach was along the M0 expressway, where environmental status surveys were accomplished before and during construction and a year after its opening (case study no. 1).

The level of environment pollution and its dependency on traffic intensity **can be well monitored** by the above studies. Monitoring sites with different traffic level were determined along the roads of national importance (motorways, main roads). Monitoring activities at these sites primarily aims to follow the quality changes of **soil, water and vegetation.**

Wildlife (nature) monitoring systems of all the motorway sections constructed and opened in the past one and half decades have not, or have only partially fulfilled the professional requirements of monitoring studies. The longest data collection interval was not longer than five years. Even the focus of studies were questionable concerning base requirements of biological indication. Trends in supraindividual systems affected by a newly opened road should be the subject (*indicandum*) of a monitoring activity, as for example changes in vegetation structure, trends in breeding bird communities, alteration of amphibian or large game population sizes or behaviours. Analysing consecutive bird occurrence lists of one or two years can not be considered as a real monitoring (the monitoring budget of some hundred thousand HUFs a year usually allows only such a study scope). Consequently, these ornithological checklists cannot fulfill the requirements of an environmental study.

All, all the expected effects on nature of a planned road section have to be defined accurately in the preparatory licensing phase of road design within the detailed EIA. Aims, objects and indicators of biomonitoring have to be defined on the base of the expected environmental effects. (Indicators are those organizations which clearly detect and reflect – by their occurrence/lack, change in population size, in distribution or in other behavioural variable – an environmental factor or the status change of an environmental factor.) The Hungarian designing practice routinely requires (or compiles) the detailed plan of the necessary nature monitoring studies as early in the planning processes as possible (during the licensing phase). Certainly the content of the monitoring plan should be harmonized with and accepted by the relevant nature conservation authority. The results have to be accessible by relevant nature conservation authority as well as by designers. Today the results are not public. Time interval of nature monitoring should be set to a minimum of 10 years.

7.7. Summary

A great number of environmental establishments were constructed along the Hungarian road network especially in the last 15 years financed from about 5–10% of the total construction budget. About one tenth of the environment protecting means (culverts, noise reducing walls etc.) are wildlife protecting structures. There are no guidelines for planning nature conservation measures, the efficiency of the realised protection measures are seldom followed up by wildlife monitoring programmes.

Among nature conservation measures, the ones protecting game (fences, passes) are the greatest investments in volume and in numbers as well. An obligatory part of concessioned motorways is the wildlife fence. However, nobody studied yet the habitat fragmentation effect of fences (made for safety purposes at first instance) in details. The segregating effect of fences on game populations cannot be neglected. Thus steps should be made toward a more extended use of other measures decreasing collision risk (light reflecting prisms, odours).

Only the big game bridges of the M1 Motorway were studied during operation. Monitoring status and efficiency of big game passes is of prime importance for nature conservation (because these establishments decrease the fragmentation effect of linear infrastructures) and for the designers (for the purpose of planning cost-efficient establishments) as well.

Concerning amphibian, reptile and small mammal passes the experience gathered is more than enough in Hungary. However, compiling a suitable planning guideline is the task of the near future.

An everyday task of investors is vegetation planting (and sometimes the translocation of species) thus there is an urgent need for reviewing the methodology at a national scale and for a planning guideline accepted also by the nature conservation sector.

Chapter 8. Habitat fragmentation and future infrastructure development

8.1. Introduction

There is a continuous increase of mobility demands in Europe and in all developed countries of the world. The effective operation of the united European market strongly depends on unhampered, fast, safe and economical transport of passengers and goods. This huge mobility demand is satisfied mainly by road transport, 90% of all passenger transports and 70% of freight transports are directed to roads.

Conforming all above the establishment of a Pan-European road network deserves high priority. The founding document of the European Union – enacted in 1993 – provides the opportunity of supporting and promoting the development of road network out of the Union as well.

The Parliament Decree no. 68/1996. (9. July) defines the main trends of the Hungarian transportation policy as follows:

- to promote the integration to the European Union,
- to improve the conditions of co-operation with the neighbouring countries,
- to promote the well balanced regional development of the country,
- to preserve human life and environment,
- to operate traffic and transportation effectively and in conform with the market.

The transportation policy of Hungary mentions the European integration at first place not by chance. Transportation – and especially the development of motorway network and its links to the European network – will prospectively be a topic of outstanding importance during the acquisition negotiations.

It is of high importance to represent the mature and approved (by the Government and by the Parliament) long-term policy plan defined by legislatory means during negotiations. The "Long-term development plan of the Hungarian motorway-expressway network" should be approved as law within the frame of the Regional Policy Plan of Hungary (OTT) under preparation. Both the OTT and the motorway-expressway network development plan have to serve basically a more equalized regional development of the country and would consider the possibilities of strengthening the social and economical relations with the neighbouring countries by joining the international motorway-expressway network.

The long-term development plan of motorway-expressway network is under conciliatory negotiations with the neighbouring countries at ministerial level. Integration of actual tasks with Romania, the Slovak Republic and Slovenia has already been initiated.

The most important public road network development task regarding the promotion of the EU acquisition is the acceleration of motorway-expressway network construction. Five of the Pan-European transport corridors cross Hungary and their development priority is set by the Government Decrees no. 2119/1997. (14. May) and 1085/1997. (24. July).

The aim of the motorway-expressway network plan of Hungary is to define the necessary connecting corridors between regions and settlements in medium-term (until 2008) and in long-term, i.e. until the total motorization (2030 expectably) and moreover to codify the plan.

The importance of connections instead of layout (route) definitions has to be stressed. Accurate layout selection and elaboration of feasibility conditions (financing schemes) do not belong to the long-term planning. The codifying process has to insist on approving the connections for the interest of making the medium-term and long-term plans of motorway and expressway networks, and to disseminate the plan for the domestic and foreign inquirers and potential investors.

8.2. Policies and strategies/trends

Network development strategy

The objectives of a motorway-expressway network development can be drafted as follows:

- to promote the international and inland network connections and to satisfy transportation demands,
- to improve the road conditions (decreasing accident risk, travelling time and transportation operation costs) for the interest of relieving spatial inequalities of the country by rendering a harmonic regional development policy possible,
- to reduce the adverse environmental and natural effects of transportation,
- to increase transportation efficiency.

Recommended construction standard

The proposed elements of the motorway-expressway network development plan are motorway sections of 2×2 and 2×3 traffic lanes and expressway sections of 2×2 traffic lanes.

Principal difference between motorway and expressway is their different service level. Expressway is usually designed for lower speed and less traffic lanes, separation strips and shoulders can be narrower. As the plan recommends, the development of the expressway network can partially utilise certain elements of the existing principal road network, namely by widening them (up to 2×2 lanes). This recommendation is not only economical but environmentally beneficial as well because it does not require as much natural area for the transportation corridor than designing a new route. At the same time, the suitable development of the connecting secondary road network will have to support the traffic of slow-running vehicles and machinery excluded from the former main roads transformed to expressways.

The draft plan recommends motorway for all important international corridors and for areas where the intensive inland traffic deserves it. Important international corridors are the traces of M1, M15, M3, M30, M4, M43, M5, M7 and M70 motorways with intensive traffic already at present, as well as the corridors Tornyosnémeti – Miskolc – Debrecen – Ártánd (M30, M3, M35, M40, M47, M4), Budapest – Szekszárd – Illocska (M6, M56) and Füzesabony – Szolnok – Kecskemét – Dunaújváros – Székesfehérvár – Veszprém (M8) the importance of which depend on requirements of international agreements and on capacity demands. For the purpose of relieving the M7 Motorway at the Lake Balaton an alternative trace for the Helsinki 5th corridor was designed along the Letenye – Kaposvár – Dombóvár – Dunaújváros – Kecskemét – Szolnok – Füzesabony (the existing M61, M8 roads) direction. The proposed layout relieving the 4th primary road follows a new route and offers expressway level, meanwhile does not exclude the possibility of further development of the road to a motorway depending on traffic development. Moreover, motorway level is offered for the final construction of the M0 expressway (Budapest). The draft motorway construction standard proposes

2×2 lanes except for certain sections of the M0 expressway and for the Budapest – Szabadbattyán section of the M7 Motorway, all requiring 2×3 lanes in the distant future.

Networks investigated

The studied roads of a sum 30.000 km length represent the national public road network and can be considered as the basic network. The existing motorway-expressway network, the primary and secondary road systems and those parts of their connecting inferior road networks which have significant corridor function are all included in the study.

Only those new motorway-expressway elements of the planned network have already been planned in details which will be established in the near future. Although designers attempted to plan routes as precisely as they could, these routes should be considered "corridors" only because a trace is effective and determined only if all necessary licensing plan phases and procedures are successfully implemented and a valid building permit is received.

After the full establishment of the motorway-expressway network the service level will be as follows:

- all corridors belong to international road network are motorways or expressways,
- most important road connections to the neighbouring countries will be of motorway-level,
- all counties and county-seats will have connection to the motorway-expressway-network, the network will improve the connections between county-seats,
- travelling time between the capital and the counties, county-seats will be shorter.

Planned developments

The development plan recommends two phases for establishing the motorway-expressway network:

- in medium-term until the year 2008, and in (Figure 8.2.1) long-term until the year 2030. (Figure 8.2.2.)

The medium-term development proposal of the motorway-expressway network recommends the accelerated realisation of planned motorways and expressway-transformations to motorways both supporting the economic policy and the European integrational interests of Hungary.

Road density of Hungary (both of national and of local roads) is similar to the road density of the EU countries (however, service level is less developed). The most important difference is the lacking motorway-expressway network. This is reflected by the motorway-expressway density data of 4.5 km for 1000 km^2, which is extremely low if we consider the corresponding data of for example the two small countries of the EU. The motorway-expressway density is more than 50 km for 1000 km^2 in Belgium and in The Netherlands.

In relation to EU integration, the most important parts of road network development are the ones supporting international relations.

Total length of the accepted Helsinki corridors' sections to be constructed by Hungary is almost 750 km. Government Decrees (no. 2119/1997, no. 2117/1999, no. 1037/2000) ordered the construction of about 51% of this network (460 km) until 2008 (Figure 8.2.1.). This part of the network can be considered as medium-term phase of the motorway-expressway network development plan.

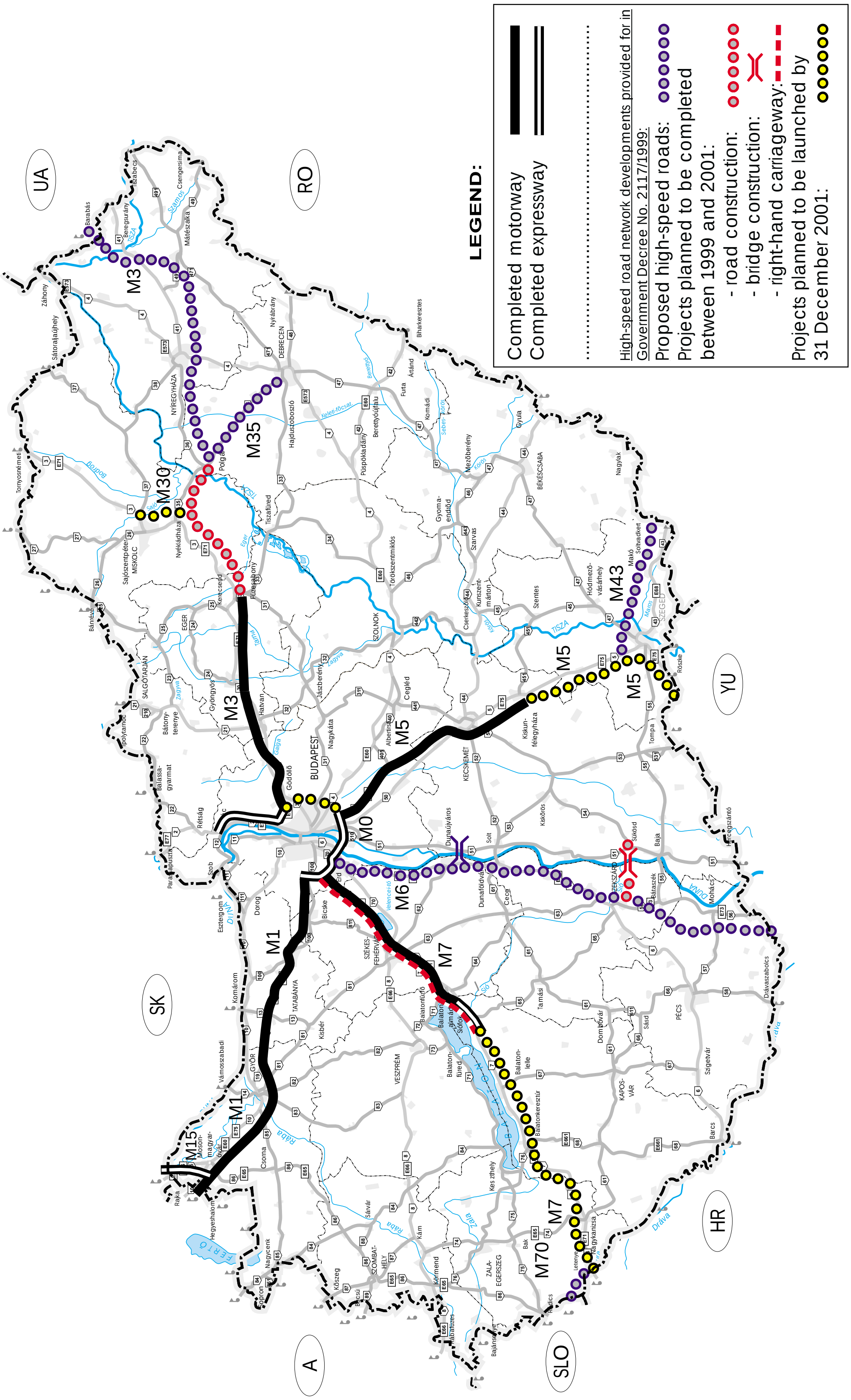


Figure 8.2.1. 10-year development programme for the Hungarian high-speed road network

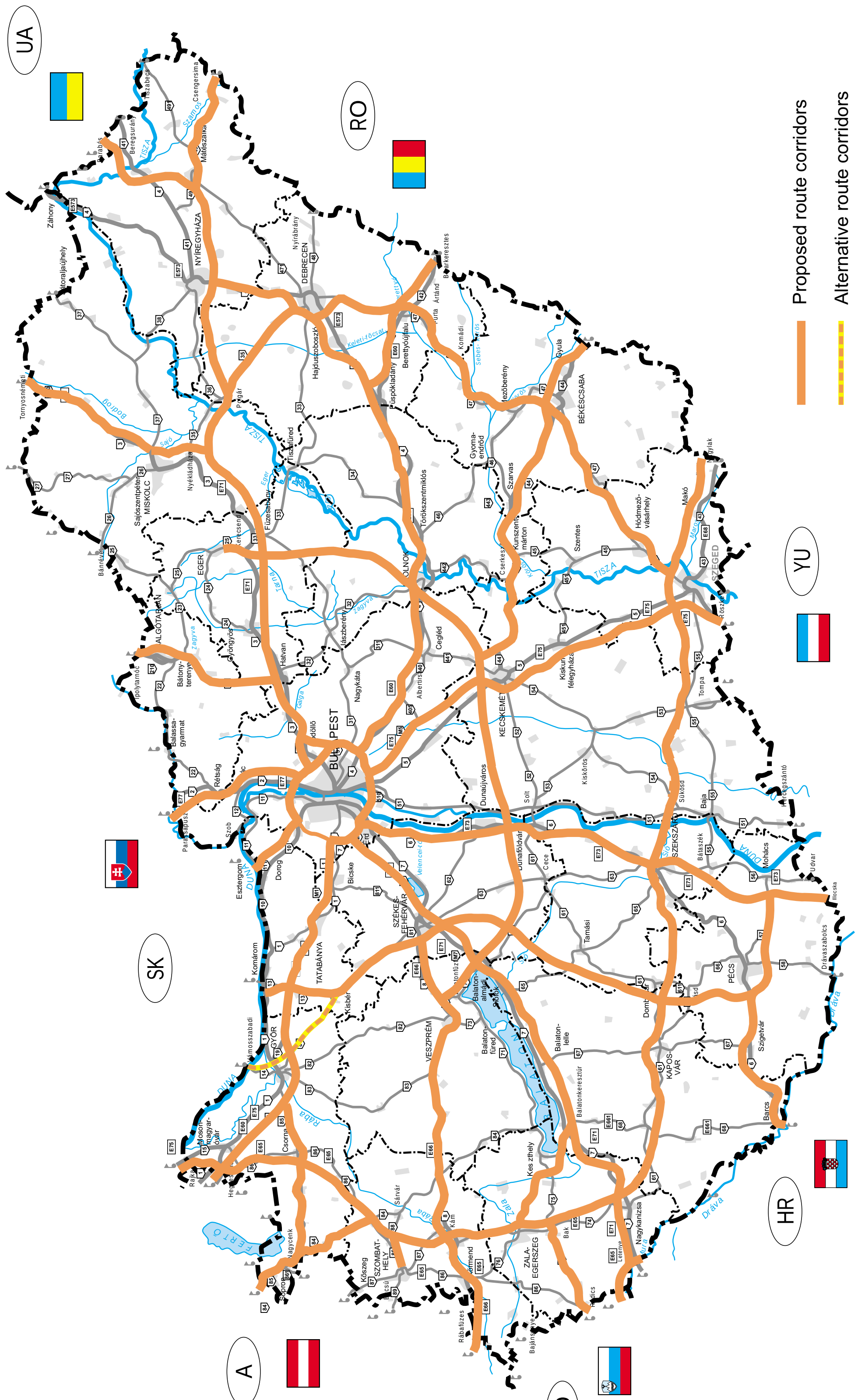


Figure 8.2.2. Hungarian high-speed road network in 2030 (planned).

The draft long-term motorway-expressway network development plan was elaborated for the interval until about 2030, by that time the forecasted level of motorization will be 430 cars/1000 inhabitants. The motorway-expressway network after accomplishing the long-range development plan will be about 3470 km long about 2240 km of which will belong to motorways and about 1230 km to expressways (based on the recent traffic intensity apprais-als).

Among expressways, several sections (with a total length of 470 km) will be developed gradu-ally from existing elements of the road network. The construction of about 770 km long new expressways (with 2×2 traffic lanes) is expected.

Key routes of European integration

Road transportation has outstanding role in the field of passenger and goods transport of the European Union as well. The establishment of the express railway network and the develop-ment of the combined transportation will presumably not withdraw so much transport volume from the roads that would significantly alter the present ratios and trends.

Inland corridors important for the Union (labelled with “E”) are practically of motorway level or efforts are shown to develop them to motorways.

Regarding EU integration, the most important parts of road network development are the ones supporting international relations (Figure 8.2.2.).

A Pan-European initiative was launched for integrating the transportation policy of Western and Eastern Europe. Its main aim was to develop an effective Pan-European transportation network (including public road transport and motorway network). Participants of the confer-ence held in Crete in 1994 designated the transport corridors important for the EU and support-ing the development of the countries at the eastern border of the EU. These corridors were amended in the Third Pan-European Transportation Conference at Helsinki, 1997 (23–25 June). The approved transportation corridors of Hungarian importance are demonstrated in Figure 8.2.3.

The roads that coincide with these corridors are the most important ones concerning EU inte-gration and international motorway traffic connections. The following motorways (also listed in the draft Hungarian Motorway-Expressway Network Development Plan) fit to the Euro-pean corridors in Hungary:

- 4th Helsinki corridor: M1, M15, M1, M5, M43 motorways, Bratislava/Wien – Budapest – Constance/Saloniki
- 5th Helsinki corridor: M70, M7, M0, M3 as well as M70, M7, M61, M8, M3 motorways, Triest/Koper – Ljubljana – Budapest – Ungvár
- 5/B Helsinki corridor: M7 motorway, Fiume – Zagrab – Budapest
- 5/C Helsinki corridor: M6, M56 motorways, Plocse – Sarajevo – Eszék – Budapest
- 10/A Helsinki corridor: M5 motorway, Belgrad – Novi Sad – Budapest.

These are the motorway connections of Hungary requested from the neighbouring countries on one side. On the other side they are inherent parts of the Pan-European motorway network basically important for the economic cooperation and trade relations between the member states of the Union and their neighbours.

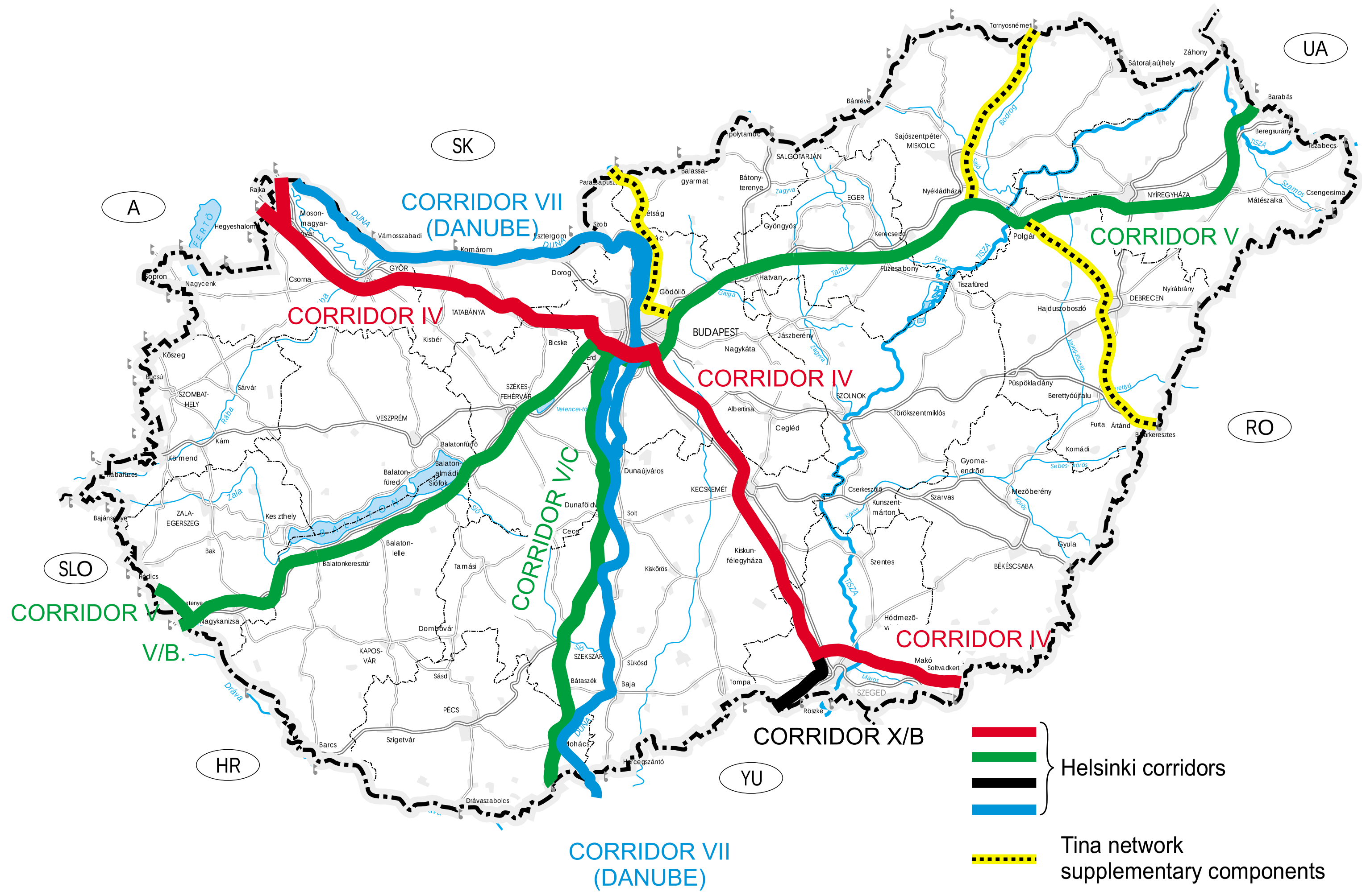


Figure 8.2.3. Helsinki corridors and Tina network supplementary components.

8.3. Indicators and indexes of fragmentation

Habitat fragmentation is the dissection of habitats (ensure the survival of living creatures). Habitat fragmentation by roads decreases physical size and dissects a given habitat patch at first instance. Several possible indicators can be found, and those meeting the following requirements may be used in various studies and monitoring tasks:

- are theoretically well-founded,
- have numerical value which easen comparison,
- well describe the degree of fragmentation for a given species group.

Theoretically the value of fragmentation is the **difference between the average habitat patch size of a given species or species group in natural (semi-natural) circumstances and in disturbed environment**.

However, the calculation or definition of this value face several methodical difficulties. The first problem is choosing the basic status (time) because of the restricted data of past status surveys. Owing to this the indicator used for habitat fragmentation can be:

- the extension change of a known or presumed habitat, or,
- the change in population number; while,
- the number of run over animals can be a special indicator.

Numeric values regarding factors causing habitat fragmentation are:

- road density,
- traffic intensity.

The digitized spatial information model, elaborated within this project describes fragmentation effect twofold:

- by the decrease of the average habitat patch size, where the main factor was the patch number increment,
- by calculating the area/contour ratio which showed the average patch character in every road type crossing the various habitats.

8.4. Summary evaluation

Regarding habitat fragmentation some statements about the Hungarian motorway-expressway development maps (see Figures 8.2.1. and 8.2.2.) have to be made regarding landscape and nature protection.

Hungary undertook to establish the “Helsinki corridors” thus the network development is unavoidable. This development will cause further landscape fragmentation. Consequently if the Regional Policy Plan of Hungary (OTT) will be accepted officially than this will be the legal base for dismembering (fragmenting) the macroregions of Hungary. The National Authority for Nature Conservation of the Ministry for Environment is the authority for preserving natural areas besides protected areas and consequently will take part in the decision making process of the plan above.

Analysing the route directions in details without aiming completeness, the following opinions evolved.

It is entirely unacceptable from landscape and nature conservation aspects:

- the realisation of the M0 expressway at the Buda section,
- the Barabás section of the M3 Motorway from the point of view of protecting the Bereg landscape as a unit,
- the M9 expressway section at the vicinity of Őrjeges.

Other route options surely affect areas that deserve careful treatment for the sake of preserving biodiversity but no exact information was accessible about these varieties (for example in the Bakony region, at the Őrség offset, the Vend region, the Hernád valley and others).

If the Government approves the network development policy in its present form and with the existing draft corridor direction, than the nature conservation aspects of selecting the best layout within the planning corridor (described in chapter 7.2.) have to be followed as far as possible. Wise selection of the best layout will bypass valuable habitats and will prefers arable lands and intensively cultivated grasslands (less valuable from the point of view of nature conservation). To ensure the safety of water regime and related protected associations the best layout is the one that follows the highest reliefs. For the sake of landscape protection a layout that follows land-use type boundaries will be the best choice.

Forecasting the effects of the drafted long-term transportation network is impossible by our knowledge. The potential of forecasting habitat fragmentation effect will be raised by the monitoring results of susceptible habitats.

Chapter 9. Economic aspects – rentability of investment, prices, cost-benefit calculations, finance

All structures and measures belonging to a new linear infrastructure have to be financed by the investor (among them the ones required for protecting environment). Costs of establishing the environmental protecting structures form a part of the investment budget. During the inauguration process, all authorities control the realisation/existence of the formerly approved structures. Authorities are entitled to control the construction and to assure technical supervision at the investors expense. Costs of research and development emerging during planning are also to be paid by the investor.

Investor orders a feasibility study in a certain phase of the planning – usually before the license plan or around that. Cost-benefit calculations are important part of these studies. The source of calculations are the expected investment costs including costs of environmental measures, vehicle operating costs, time costs, accident costs, as well as management and operation costs per unit. Afterwards the experts calculate the cost/benefit ratio, the internal return cost, the immediate efficiency and the time of return.

Beyond cost/benefit calculations and indexes (necessary for financing) there are other benefits of realising an infrastructure establishment that are hardly or indirectly provable and are only partially or impliedly covered in the above feasibility studies. For example, if an establishment relieves living areas, substitutes cross-town links or decreases accident risk, than the establishment has significant environmental benefits even if the costs of the extended environmental protecting measures are considered.

Chapter 10. Summary

Status of Hungary concerning infrastructure and natural state greatly differs from that of the Western European average. Service level of transportation network is much lower and at the same time the total coverage of natural or semi-natural habitats are significantly greater (about one fifth of the country area). An addition to these is the favourable natural conditions of the country (Continental and "mediterran-like") originating from its transtional climatic situation which results in a mosaic of diverse habitat types. In accordance with the consequently high biodiversity, the status of nature conservation policy is well-developed. However, not all areas worth for protection are designated, 9.1% of the total area of Hungary is protected, which is close to the desirable 12% (area of the nine national parks is 440.839 ha, area of the 38 protected landscapes is 349.242 ha, and the 140 nature conservation areas have 25.793 hectares protected). Species listed in the Hungarian Red Data Book and protected species lists are professionally relevant. The law of nature conservation reflects the relative values of nature as well, since it belongs to the strong laws in an European context.

Very few specialised studies about habitat fragmentation were carried out in Hungary until now, the present COST project has driven attention to this topic. We have to stress that scientific knowledge and competent experts are to be found in Hungary practically at the same level than in western Europe. Our challenge of wisely developing the infrastructure while preserving natural values as far as possible, is extended moreover by the COST 341 project. Hopefully all designers and decision makers will know that botanical, zoological and ecological knowledge have principal role in planning if we want to preserve nature. Nature can be protected *in situ,* exclusively on its own habitat. The principle of sustainable development has to be applied while developing infrastructure. It can be stated, that the **preservation of natural values can be obtained primarily by choosing the best layout for linear infrastructures.**

In the present report the structure and basic data of linear infrastructures together with their effects on nature were discussed. The habitat fragmentation effect of linear infrastructures deserved special emphasis. The characteristic feature of transportation networks affecting the spatial structure of Hungary is the heavily centralised and the radiating design. Common country level feature of both the road and the railroad transportation is the lack of transversal connecting elements, namely the corridors (of suitable capacity) between eastern and western regions which – at the same time – would relieve Budapest and its Danube bridges. This feature results in the overburden of roads going to and from Budapest on one side and in the low level of cooperation between the two parts of the country separated by the Danube.

Relatively few researches dealt with habitat fragmentation effects of linear infrastructures – among them of roads – in Hungary. Their results, however, show significant difference between roads depending on their size and traffic intensity. The effects of narrow (paved) roads with little traffic is insignificant if compared with motorways or expressways the fragmentation effect of which is really strong. Even wider roads, do not alter the vegetation further from the road but do hinder propagula spreading. This effect leads to a poorer vegetation in the long-run. Habitat fragmentation effect of roads seems to be more important in the context of invasive weed species and other disturbance tolerant species which all utilise roads for spreading fastly to new habitats.

Environmental effects are more complex in the case of animals. Contrary to the expectations, no significant lead accumulation was found rarely in animals (and plants) living along roads. However, segregation is well demonstrated in certain animal groups (mainly in amphibians) where the number of animals in collision is so high that it surely affects population dynamics and demography. Fenced motorways similarly segregate big game populations. We have less knowledge about insects, but the fact that wider roads distract several insects (even if they fly well) is well known and thus roads hamper the movement of these species.

Comparing to Western Europe, only few establishments (frog tunnels, game bridges) were made for supporting animals crossing roads. The study of animal passes showed that animals mainly do use them and that certain modifications are necessary in their design in the future.

A great number of environmental establishments were constructed along the Hungarian road network especially in the last 15 years. However, **there is no guideline for planning nature conservation measures, and the efficiency of the realised protection measures are seldom followed up by wildlife monitoring programmes.**

Among wildlife protecting means, the game protecting ones (fences, passes) are the greatest investment in volume and in numbers as well. An obligatory part of concessioned motorways is the construction of wildlife fences. However, there are no studies so far about the habitat fragmentation effect of fences (made for safety purposes at first instance) in details. Steps should be made toward a more extended use of other measures decreasing collision risk (light reflecting prisms, odours).

Concerning amphibian, reptile and small mammal passes the experience gathered is more than enough in Hungary. However, compiling a suitable planning guideline is the task of the near future.

A nationally and internationally unique spatial information program was initiated by the COST programme. Experts attempted to create a model for the habitat fragmentation effect of the road network on the base of the existing digital databases. They drafted the road network and nature conflict map the utilisation of which should be tested and improved in the near future.

The transportation policy of Hungary was developed in relation to the European integration. Transportation – and especially the development of motorway network and its links to the European network – will prospectively be a topic of outstanding importance during the acquisition negotiations. It is of importance to represent the mature and approved (by the Government and by the Parliament) long-term policy plan defined by legislatory means during negotiations. The “Long-term development plan of the Hungarian motor- way–expressway network” is to be approved as law within the frame of the Regional Policy Plan of Hungary (OTT) under preparation. The most important public road network development task regarding the promotion of the EU integration is the acceleration of motorway-expressway network construction.

Main transportation corridors, the development areas for the next 30 years are defined already. Their detailed study was launched and parallel with the detailed studies the first impact studies were finished as well in some regions. **On the base of the present report it would be worth revising the older plans, schemes and policies or creating new ones for the purpose of finding the best transport corridors and routes to serve nature conservation.**

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