Key Concepts in Landscape Ecology. IALE(UK), Preston
Edited by J.W. Dover & R.G.H. Bunce

Biocorridors - theory and practice

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Abstract

A network of refuges and linear formations of seminatural and near-natural vegetation in the agricultural landscape is generally considered to have an essential significance for survival and migration of animal species and for landscape stability and biological diversity. Experimental attempts at establishing the spatial and ecological parameters of the refuges and corridors are however few in number and, contrary to general theoretical assumptions, give contradictory results.

The methodical aspects, factors complexity, regional differences in climate and habitat preference of species are considered to cause such contradictions. Their problem is discussed on the base of experiences obtained in the study of carabid beetles. The regional approach is recommended for establishing corridors and refuges parameters.

Finally, an empirical attempt at establishing of spatial parameters of the landscape stabilising elements tries to substitute the lacking experimental information by estimates of experts having been introduced into practice in Czechoslovakia in early 1990-ies is presented.

Introduction

The island biogeography has generally been accepted as a theoretical basis for the study of community structure in different habitat mosaics in human changed landscapes. In spite of the evident analogies there are however, considerable differences between an island in an ocean and an isolated patch of seminatural or near-natural vegetation as an "island" in an "ocean" of ecologically less stable agricultural landscape. The number of species colonising an island is usually registered without respect to their ecological properties. On the contrary, in landscape ecology we put great stress on the ecological properties and sosiological value of the species inhabiting a landscape segment or we only try to modify the species composition in some type of ecosystem, which as such may exhibit a surprisingly high species diversity. The salt water offers to terrestrial or fresh-water organisms extremely and constantly unfavourable live conditions making possible, except for most birds and insects, only the passive migration. On the contrary, even strongly disturbed surroundings of a natural biotope allow a certain degree, some stenotopic species to survive and migrate. Permeability of a barrier represented by an extensive water surface is constantly very low for terrestrial organisms, but permeability of a landscape segment for a specialised species group varies seasonally, according to climate, momentary weather or intensity of landscape uses. Biota of an island has being formed usually during a much longer time than fauna of an isolated vegetation patch in a man disturbed landscape.

All these factors and their exciting variability are responsible for the considerable difficulties we meet in our effort to find out methods how to increase the ecological stability and biotic (sosiological) value of the intensively exploited agro-industrial landscape and how to find out spatial and ecological parameters of the stabilising landscape elements like (bio)corridors and refuges (biocentres).

Practical problems of assessing parameters of the corridors and refuges - a view of an entomologist

Contradictory results of field investigations

A mechanic application of some spatial parameters of refuges and corridors or purely theoretical principles may be sometimes misleading even within one ecologically homogenous area. So a little locust tree island (1/4 ha) with a relatively natural shrub and herbage stratum on the insolated south-western slope of Pavlovské vrchy hills in South Moravia hosts a very rich forest carabid fauna. On the contrary, the forest carabids almost absent in a large oak forest island (about 30 ha) on the top and moderate northern slope of a low elevation the Trnavská pahorkatina highlands in West Slovakia. A poor carabid fauna inhabits this forest in spite of its advanced age of about 90 years and about 5 km distance from a large complex of forests in the Little Carpathians.

A small island of locust trees (about 3/4 ha) in a homogenous agricultural landscape with extremely reduced woody vegetation in the Podunajská nižina landscape South Slovakia with a rich shrub layer consisting of *Sambucus nigra* and a dense herbage layer dominated in summer by *Galium* sp. serves as a refuge for a surprisingly rich population of the euryecious carabid *Carabus scheidleri* (about 200 individuals per trap and year). Emigrating individuals were recorded in the surrounding wheat fields still in the distance of 500 m. On the contrary, an 17 ha large remnant of drier type of flood plain forest (*Ulmi Fraxineta carpinea*) preserved a rich seminatural community from which the forest and euryecious specied emigrated up to the distance of 50 m (Farkač & Farkačová, 1990) similarly as from a relatively bed working windbreak (Šustek, 1994a). An approximately 3 ha large island of a ca. 30 years old poplar monoculture (cultivars of *Populus canadense*) situated in the same lowland about 20 km southerly having a similarly rich shrub layer formed by *Sambucus nigra* and a mostly grassy herbage layer was inhabited only by a poor assemblage of few carabid species occurring abundantly in the surrounding wheat or maize fields (in average 23 individuals per trap against 200 - 800 in the field, 12 species against 55), (Šustek, unpublished).

Some possible causes of contradictory results of field investigations

Experiments arrangement and habitat "cryptoheterogeneity"

The strikingly contradicting conclusions made by some authors (even by the same author, Pavuk *et al.* (1997)) in regard of the role of field margins, grassy strips or windbreaks as corridors or wintering places (e. g. Tischler, 1948; Inyaeva, 1963; Górny, 1971; Desender *et al.*, 1981; Doane, 1981; Andersen, 1997; Kabacyk-Wasylik, 1997; Kiss *et al.*, 1997; Šustek unpublished)) or weeds management (e. g. Pavuk *et al.*, 1997, Schellhorn & Sork, 1997) may result from the observations arrangement and false assumption of the homogeneity of the conditions in a field.

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A deeper analysis of results interpretation problems in studies on impact of different fertilisers or pesticides on soil fauna (Šustek, 1990) showed that there exist a relatively stable between-year pattern of isobars of species richness and abundance in the investigated fields. This pattern reflects very slight local differences in soil humidity or structure. Effect of such slight habitat structure differences can be secondarily increased by the differences caused by the same primary factors in the crop density or height and finally in the stand microclimate. Influence of such differences is superior to the influence of other investigated variables. In such situations, the results are strongly biased by the coincidence of such invisible and hardly measurable gradients (=cryptoheterogeneity) and of the experiment arrangement. If a boundary or a control plot is placed just in a local maximum of the insects abundance, the result may look rather good and vice versa. This is supported by Hengenfeld (1979) who showed that even differences of few cm in the trapping place altitude on a seemingly homogenous meadow may considerably influence the distribution pattern of carabids.

Different animal groups competition and/or predation.

Many field investigations in animal ecology are carried out on taxocoenotic level in which a community is represented by a group of the species which a zoologist is able to identify. The simultaneous evaluation of community structure changes of two or more ecologically similar groups along a transect (e. g. Šustek, 1994b) indicate that distribution patterns of such groups tend to be slightly negatively correlated. A good example of such relationships are carabids versus staphylinids (mutual predation, especially of larvae), carabids versus silphids represented by *Silpha carinata* and *S. obscura* (mutual food competition) or carabids versus lycosid spiders (predation by carabids, food competition). In such cases, the isolated interpretation of data including only one animal group can be considerably biased.

Landscape relief and climate

The predominating landscape relief may enormously influence the effectiveness of corridors and refuges and is to be taken into consideration in establishment of their special parameters. This opinion is supported by my field experience from North Korea. That marvellous country is characterised by predominance of granite mountain ranges with very sudden slopes. The strong monsoon rains water trickles down and disturbs the litter (even the conifer needles are lined up vertically by water). Due to it, the soil surface fauna is strongly impoverished even in almost virgin forests. Under such circumstances, the carabids in North Korea occur in large areas only as migrants. Only on small plateaus they are able to form rich communities structurally similar to those in most other parts of the palaearctic arboreal.

Influence of ecotop trophicity on the work of a corridor

The experimental observations made so far in South Moravia in carabid beetles indicate the soil trophicity to considerably influence the ability of a woody vegetation strip to work as a corridor. Corridors on rich nitrophilous or calcareous soils work better than those on poorer (acidic soils, brown soils etc.) ones. The cumulative number of individuals and biomass of catches in calcareous forests are 5 - 6 times higher than on the acidic or neutral soils. A very sharp change of community structure observed at the contact of two areas with acidic and calcareous soils (Šustek & Žuffa, 1986) indicate that the migration stops in such situations.

Seasonal and temporary changes of the corridors permeability and impact on surrounding fauna

Occurrence of forest Carabids like *Carabus coriaceus, Carabus nemoralis* and *Abax ater* in a system of discontinuous woody vegetation corridors and randomly scattered groups of shrubs on the western slopes of Pavlovské vrchy hills in South Moravia, (Šustek, unpublished) considerably increases after the colder rainy periods. These species (1-2 individuals per traps and month) occurred, in such periods, even in the most isolated places where under normal circumstances were not recorded. Similarly the cold rainy periods, first of all in late autumn, allow the forest species to penetrate even into patches of natural xerothermic steppe-like vegetation, where in spring and summer very few individuals of the extrazonal populations of steppicolous species like *Carabus hungaricus, Zabrus blapoides* are active.

Similarly a stand of dense and high grass on meadows diversified by a dense network of woody hedges in the submontane area of the Slovenský Kras Karst (annual precipitation of 800-1000 mm, altitude of 700-800 m) allowed intensive spreading of the forest Carabids and Staphylinids like *Pterostichus foveolatus, Carabus violaceus, Carabus hortensis, Ocypus macropterus* over whole area (Šustek, 1994c). This species disappeared from the meadows just after mowing or they concentrated in the karst sinkholes in which the grassy stands were not affected by mowing. On the contrary, in an analogous situation in high montane conditions in Malá Fatra mountains (annual precipitation1400-1600 mm, average temperature in July 10 °C) such migration was not observed.

Emigration rate of a rich population of *Carabus cancellatus* from an oak-hornbeam forest easterly of Pavlovské vrchy hills in South Moravia (6-8 individuals per trap and month) into neigbouring wheat field, culminated shortly before the wheat ripening (3-4 individuals per trap and month in the distance of 20-50 from forest margin, 2-1 ind. per month and trap in the distances of 50-100 m and 0-1 ind. in the distance of 100-200 m). Immediately before harvesting the beetles did not emigrate, emigration restarted in autumn, after the sowing of that field.

On the contrary, an investigation on impact of deforestation on the preconnubial aggregations of Sarcophagid flies males (Povolný, Šustek 1982) has shown that, in early spring, the open land species (e. g. *Sarcophaga carnaria, Sarchophaga schulzi*) easily penetrate deep into the not leafed beech forest. Their immigration stops immediately after full leafing.

These facts show that even a system of discontinuous corridors can work and play a role of stepping-stones in the agricultural landscape. Intensity of its work, however, vary seasonally. Discontinuities of woody corridors of about 10-30 m seem to be acceptable. Their acceptability is supported by the effective mechanisms how to search for a more favourable patch in the habitat mosaic some animals have developed. The forest carabids having been experimentally set out in an open landscape tend to migrate to an artificial dark silhouette simulating a forest stand on the horizon (Thiele 1977).

The above facts also indicate a possibility to consider some vegetation formations to be substitute corridors for species of different habitat preference and, at the same time, they

support the necessity of regional approach to solution of problem of corridors and refuges parameters (see below).

Corridors parameters versus intensity of arable land use

A decreased intensity of arable land use under almost unchanged landscape structure can positively influence the field fauna structure. This could be observed in Czechoslovakia a few years after the political changes of 1989. The halt of financial support for agriculture, the nominal stagnation of agricultural products prices and a high inflation rate meant a considerable decrease of prices of agricultural products and an enormous increase of all input costs. All these factors caused abandoning of some fields and a considerable reduction of the use of chemical fertilisers and pesticides. This situation made possible a rapide increase of population density of many species (e. g. *Calosoma auropunctatum*, some *Carabus* species) which earlier seemed almost extinct in the arable land. These ecologically positive changes were realised by amateur entomologists (personal communications). Unfortunately, nobody expected such changes and started a serious long term monitoring which would allow to evaluate exactl evaluation.

Zoocoenotic differentiation of fauna

Creation of a corridors network in a landscape should respect zoocoenotic differentiation of animal communities inhabiting externally similar biotopd. E. g. there is a deep difference in composition of insect fauna in natural flood plains and mesohygrophilous lowland forests. Along a continuous catena from the river banks to wider surroundings, the carabid communities of both forests types changes fluently and their spatial distribution sensitively reflects the annual fluctuation of floods extent and groundwater level. Even if the water regime of a landscape segment was artificially changed, such configuration allows the communities to turn fluently to an other type. But most typical flood plain forest carabids do not survive in the mesohygrophilous forests. If the continuity between the typical flood plain forests and the mesohygrophilous ones is broken by an extensive area of arable land, the floodplain fauna becomes isolated and most species are unable to migrate through most artificial windbreaks. In such situations even some substitute communities may be more effective (see below).

A similar relationship exists between field communities and extrazonal islands of natural steppe like communities (group of geobiocens *Corni Querceta* deg. (Zlatnik, 1976)) and fallows in warmer parts of Central Europe whose succession converges to such steppe like communities. Such biotops are inhabited only by a few individuals of highly xerophilous species (e. g. *Dyschirius rufipes, Licinus cassideus, Zabrus blapoides*). Only extrazonal population of the typical stepicolous *Carabus hungaricus* may reach a considerable size. The border between such fallows and adjacent fields richly populated by typical "field" species is extremely sharp.

Inevitability of regional approach to establishing the corridors and refuges parameters

Regional climatic differences

Agriculture in the zone of the holarctic arboreal forms everywhere, in principle, similar landscapes structures. Their regional differences result mainly from the land ownership

relationships, landscape relief, lands accessibility and usability. So, wider hedges grown by woody plants regularly scattered in the agricultural landscape could arise only in highlands where the slope declination forced the farmers to form gradually terrace-like field strips or where the stony soil forced them to collect the stones and put them on the lands margins. On the fertile lowlands, the woody vegetation is strongly reduced. Its reduction reflects an equilibrium between the size of the fed human population, emphasis put on agricultural production and possibility to provide fuel and construction material from more remote sources. Independently whether it is the "bocage" in Brittany a windbreak in South Moravia and Slovakia or in lowlands in East China, the woody vegetation forms only narrow boundaries between the land pieces or alleys along lanes, water flows, springs, religion symbols etc. Therefore the differences in degree in which the line formations of woody vegetation in individual regions work as corridors for forest animals depend primarily on three factors: (1) - the climatic gradient between the local types of forests and the open landscape, (2) how the microclimate of the line formations approximates the microclimate of the forests, (3) connectivity and representation of continuous woody vegetation. The larger this gradient, the less forest species are able to emigrate into the fields and the shorter are distances up to which they emigrate. Similarly in the absence of continuous woody vegetation in a landscape (some parts of South Slovakia) disables the existing line formations of woody vegetation to work as corridors.

Table 1. Rough differences if some climatic characteristics of individual parts of Europe (data according to Klima *et al., 1967*).

	NW Europe*)	Central Europe	South Moravia
Average temperature in January°C	0 - 5	-5 - 0	-2 - -3
Average temperature in July°C	15-20	20-25	20 - 21
Months with average temperature < 0°C	0	3	2
Months with average temperature >20°C	0	1	1
Annual precipitation [mm] in lowlands	750-1500	400-500	350-450

*) Great Britain, Northwest France

The line formations of woody vegetation in northwest Europe work in the typical oceanic, humid and more balanced climate than those in central Europe. Therefore the "bocage" in Brittany can offer suitable conditions for survival of metapopulations of the typical forest carabid *Abax paralellepipedus* (= *A. ater*) (Petit, 1994; Charrier *et al.*, 1997) while a network of windbreaks in South Slovakia can not (Šustek, unpublished) in spite of the facts that they are mostly wider and denser the "bocage" and that reduction of forests in Brittany and South Slovakia is similar. On the contrary, the connectivity of the windbreaks studied by Šustek (1992, 1994a) in South Moravia with the original deciduous stands allows them to work rather effectively in almost identical climate as in South Slovakia.

Variability of species habitat preference within distribution area

According to regional climatic differences, individual animal species exhibit considerable differences in their habitat preference and anthropotolerance within their distribution range. One of such species is the Carabid *Carabus nemoralis*. In the Central Europe, it is a stenotopic forest species. It neither uses to penetrate into the cities nor into the arable land, but it occurs in a small number of individual wider windbreaks connected with a forest or situated not too remote from it. On the contrary, in more humid and cold climates of central Russia it is able to survive successfully even in the central parts of Moscow, where the trampled individuals can often be found on the pavements. At the same time, in that type of climate, it easily survive in the fields, reaching a considerably high relative abundance and migrates between fields and adjacent forests (Saboleva-Dokuchaeva, 1995). On a smaller scale such a rather diversified habitat preference can be observed in *Pterostichus melanarius (= P. vulgaris)* which has even three optimum foci - probably the original one in drier types of flood plain forests in lowlands, a secondary one in the arable land and a third one in the mesohygrophilous forests in the highlands where it find higher humidity and limited competition pressure of the typical forest species having optimum in lowland forests.

Problems of an adequate ecological characteristics of some species

Characteristics of species habitat preference presented in many ancient entomological books (e. g. Reitter 1909-1915, Burmeister 1939) are mostly uninformative. Many species were supposed to live almost anywhere, "fields, forests, hedges, gardens, dark places" or "on suitable sites anywhere" are typical of such books. Such inaccurate characteristics are many times in a deep discrepancy with the present day experience. These discrepancies resulted, in a considerable degree, from the lack of knowledge and experimental work and, from too intuitive superficial interpretation of many occasional observations. But a deeper analysis of such characteristic shows that they could have sometimes a rational heart. These observations were made in a more diversified landscape, where the less moveable species could easily find a suitable refuge. The distance between such refuges did not so often exceed the migration ability of one individual. At the same time no or almost no artificial fertilisers and pesticides were in use. So some species which seem at present to be bound only on forest could survive also in the fields. Some abundant *Carabus* species like *C. coriaceus, C. hortensis, C. violaceus* are a good example. The necessity of extensive regional studies of habitat preferenda is emphasized in last time also by other authors (Kubach & Zebitz, 1996).

Possibility to substitute some corridors by other vegetation types

The spatial parameters of a corridor, first of all their width, as such are, of course, a very important factor influencing possibility of animals to migrate through a corridor and to survive there. However, such factors like species composition of woody plants forming the corridor and the microclimate they are able to create seem to play even a more important role. There are three characteristic examples. A windbreak (10 m wide, 1,8 km long) consisting mostly of different exotic trees and shrubs (*Gleditschia, Robinia,* etc.) made possible migration of the forest Carabids in an about three times lower level than a partly discontinuous corridor (width varying between 5 - 15 m arisen spontaneously on an hedge and consisting of a variety of autochtonous woody plants). An artificial about 40 year old windbreak consisting originally only of cultivars of Canadian poplars, in which, however, a rich shrub stratum of *Rosa* spp.,

Prunus spinosa, Ligustrum vulgare, Sambucus nigra, Crataegus spp. developed in the course of time, allowed a remarkably intensive migration and survival of large Carabids *(Carabus ullrichi, C. cancellatus, C. nemoralis, C. coriaceus, C. convexus,* 8-12 individuals per trap and month). These three examples indicate the quality of herbage and/or shrub layer in a corridor and its width seems to play a more significant role in forming the internal microclimate of the corridor than the tree layer itself. Similarly, the tree crown shape and branches furcation pattern have a great significance for many birds. E. g. the uniform crowns of poplar cultivars having mostly vertically situated branches furcating in sharp angle offer to birds less possibilities to have a rest or to find a place suitable for nest construction than other tree species.

The above facts suggest a possibility to substitute effectively, in some situations, corridors of certain types for other vegetation formations creating similar microclimate at the groung. Even some types of high herbage formations or reed stands are able to substitute a tree cover and effectively protect the more or less natural soil surface fauna for a certain time. So, e .g., a high and dense cover of *Rubus idaeus, Urtica dioica, Aster novi-belgii, Impatiens glandulifera* in some clear-cut parts of the Danubian floodplain forests create at the ground surface such a microclimate that the carabid communities can survive there almost undisturbed in spite of the fact that clear cutting in other types of forests changes profoundly the carabid community structure.

Also the almost monospecific structurally homogenous reed (*Phragmites communis*) stands growing along an extremely wide humidity gradient ranging from permanently submerged stands in shallow waters to isolated islands in relatively dry places. According to this the carabid fauna inhabiting such stands vary extremely. The richest communities are formed in temporarily flooded or waterlogged stands. They consist of all 60-70 carabid species forming the communities also in the natural flood plain forests of various types. In addition the most significant species use to be represented in similar proportion as in the reed stands as in the flood plain forests. A similar role can be played by the high grassy stands in highlands.

Woody vegetation corridors and their possible influence of the field fauna

The comparison of the Carabid community structure found during the first ecological investigations in fields in mid 1950-ies (e. g. Skuhravý & Novák, 1957; Skuhravý *et al.*, 1959; Beláková, 1960) with the present day investigations shows that the main effect of simplification of agricultural landscape structure and of modern technology was extinction or a considerable reduction of populations of large (22-40 mm) species (in Central Europe *Calosoma auropunctatum, Carabus* spp., in southeaster Europe also *Taphoxenus gigas*), (Šustek, 1987). Because just the body size is a deciding factor determining ability of a predator to hunt and eat certain kinds of prey and partitioning ecological niches, it is obvious that absence of large species representing as the matter of fact one level of predators considerably changes the food web structure and predisposition of agroecosystem for biological pest control.

Because the emigration rate of the forest species from a corridor or refuge into the adjacent fields is relatively low (these species even optical search for a darkness (Thiele, 1997)) and also not all grassy strips or fallows do work as refuges for less tolerant species of the field fauna, it seems to be desirable to manage structure of a part of the corridors and refuges in the

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agricultural land in such a way to they allow existence of large eurytopic species (e. g. *Carabus cancellatus, C. ulrichi, C. scheidleri*) which are able to survive as in woody vegetation formations as in fields and in some experiments (see above) exhibited a considerable ability to penetrate in to the fields, at least in some periods. So the functional structure of little predators guild can be improved.

Possibility of research simplification

Insect communities in arable land, in spite of the enormous antropogenic presure exhibit very large species diversity and mostly also an extremely high number of individuals (500-2,000 per trap and month). Therefore the processing of the material of some insect groups, just like Carabids or Staphylinids, collected along long transections during whole vegetation period are extraordinarily time consuming. Such approach is fully legitimate from the scientific point of view, but a detailed analysis of results show, that the results obtained during a relatively short period of culminating activity of these beetles (about two months from mid May to mid July in cereals or from June to August in maize, sugar beet) are sufficient to estimated reliably the spatial parameters necessary to the corridor function properly. The results obtained during the autumnal months are not of a special information value. Similarly Maelfait & Desender (1990) conceded short-term sampling for site assessment under precondition that it will be interpreted by experienced expert.

A practical attempt in Czechoslovakia to establish spatial parameters of the corridors.

The experimental studies trying to establish spatial parameters of the corridors in arable land are few in number. Their labour consumption and the great diversity of animal communities and special methods for their study do not promise that a sufficient amount of data valid for different landscape types would be available in the close future. From this reason, the necessity to improve the landscape structure, which was deeply changed and destabilised by the collectivised agriculture (fields of 150 ha were not exception, a great part of the scattered verdure was destroyed), led in Czechoslovakia in the mid-1980-ies to an attempt to estimate such parameters on the base of empirical experiences of specialists in general ecology, geography, botany and zoology. The lacking information was obtained by means of an inquiry (Tab. 2). After an open discussion of participating specialists representing "interests" of plants and individual animal groups, the data synthesised with respect to the more sensible animal groups and to the real economic acceptance (Tabs. 3-6). In similar way a tentative classification of the significance of the main vegetation formations for the landscape stability was created (Tab. 7).

In the frame of that work, the concept of Territorial System of Ecological Stability (TSES) (Michal, 1992, Löw *et al.*, 1994, Kundrata *et al.*, 1995) was developed. It consist of a network of segments of existing natural, seminatural and artificial vegetation or of intentionally founded vegetation formations. Within the TSES, three basic types of stabilising elements are distinguished: (1) the biocentres - ecologically significant segments of landscape which allow the permanent existence of species and their natural communities; (2) the biocorridors - the

Table 2. Results of an inquiry about spatial parameters of corridors and biocentres made in a selected circle of landscape ecologists, botanists and zoologists in Czechoslovakia in the mid 1980-ies (modified according original unpublished data).

View	Biocentres size [ha]		Corridors length [m]		Corridors width [m]	
	minimal	optimal	maximal	optimal	minimal	optimal
1. ecologist	0,75	1,5	2,000	600-800	12	?
2. ecologist	can not be established		hard to establish		2-3	?
3. ecologist	can not be established generally					
Geographer	forest 0.5 grassland 0,1	the larger, the better	500-600	200-500	8	10
Pedologist	must established specially for individual regions					
Hydro-biologist	standing waters 0.1	1	1000	100	according water flows	
Meadows specialist	lowland 50 mountain 30	100 50	1000	100	50	100
Steppes specialist	according to individual cases					
Forest typologist	diameter of 2-3 heights of mature trees		2,000	the less, the better	according to community type	
Botanist	0.0001	1.0	?	?	?	?
Dipterologist	2	5	3,000	2,000	12	40
Coleoptero -logist	contradictory data		500	100-200	10-15	30-50
Ichtyologist	0.01 - 1	hard to say	1,000	10	1	10
Herpeto- and Batrachologist	Forests 10	20 - 100	5,000	900 - 1,000	tree lines 3	10
	Grasland 1	50	10,000	2,000	hedges,	
	Steppes 0.3	5 - 10	10,000	500	stony piles 3	10
	Waters 1.5	10 - 30	5,000	500 - 1,000	flowing	
	Wetlands 1	50 - 100	5,500	500	waters 0.5	2 - 3
Ornithologist	1	100	10,000, not so important		not important so much	
Teriologist	5	100	10,000	2,000	5	20

ecologically significant segments of landscape which connect the biocentres and/or support migration and dispersal of species, but they must not inevitably allow the permanent existence of all species characteristic of the respective community type; (3) the interaction elements - mostly small landscape segments which are a part of ecological niches of individual species living in ecologically less stable surroundings, they are represented e. g. by a spring, a tree group or even a solitary tree. The TSES is analogous with the most recent landscape ecological concepts in Germany (Biotopvernetzung), the Netherlands (National Ecological Network) or USA (Greenways).

The spatial parameters of biororridors and biocentres are specified for three significance levels: (1) local - for an area of about 5-10 ha, (2) regional - for an area of about 10-50 ha and

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(3) supraregional - for an area exceeding ca. 1000 ha (Tab. 3 - 6). The parameters are considered to be minimalistic. Validity of the parameters established in this way is characterised by the authors themself (Löw *et al.*, 1994) so that *they indicate only that, what the biologist know with a probability verging on certitude or that in what the biologists have found a consensus. A smaller biocentrum, a narrower or longer corridor will not inevitably fulfil all functions.*

Some parameters presented in the above tables are at the margin of the acceptability for some animal groups, especially for the ground dwelling not flying species, or for the economic sphere, but in some groups they may far exceed their requirements. These parameters are sometimes a target of criticisms from the side of specialists in various branches. The biologists, on one hand, criticise mostly too extensive schematisation and simplification of the existing problems (cf. Tab. 2), the biologically uneducated klepto- and technocracy, on other hand,

Table 3. Minimal size [ha] of biocentres of local significance (modified according to Löw *et al.*, 1994).

Community type	size
forests	3
wetlands	1
meadows	3
steppe-like communities	1
rocks	0.5
combined	3

Table 4. Minimal size [ha] of biocentres of regional significance (modified according to Löw *et al.*, 1994).

Community type	Size	
	meso- - eutrophic	oligotrophic
Forests in oak - beech-oak vegetation tiers	30	20
Forests in oak-beech - beech (oak-pine tier in Hercynian area) tiers	20	15
Forests in beech-fire vegetation tier	25	20
Forests in spruce beech-fire - spruce vegetation tiers	40	30
Stands in dwarf-pine and alpine meadow tiers	30	
Hard-wood floodplain forests	30	
Soft-wood floodplain forests	10	
Wetland alder stand	10	
Wetlands	10	
Steppe-like communities	10	
Communities on rocks	5	

Table 5. Maximal length [m] of corridors of regional significance and their acceptable interruption (modified according to Löw *et al.*, 1994).

Community type	Length	Acceptable interruption by		
		BUP	AL	OC
Forest stands	700			150 *)
Wetlands	1000	100	150	200
Meadows in 5.-9. vegetation tier	700	100	150	200
Alluvial meadows in 1.-4. veg. tier	500	100	150	200
Steppe-like communities	500	100	150	200

BUP - built up area, AL - arable land, OC - other cultures,
*) under condition that the corridor is substituted with a corridor of local parameters.

Table 6. Minimal length, widths and acceptable break [m] of the corridors of the local and regional significance (modified according to Löw *et al.*, 1994).

	Local			Regional		
	length	width	break	length	width	break
Forest stands	2,000	15	15	700	40	150
Wetlands	2,000	20	50-100*)	1,000	40	100-200**)
Meadows 1. - 4. veg. tier	1,500	20	1,500	500	50	100-200**)
Meadows 5. - 9. veg. tier	"	"	"	700	50	100-200**)
Steppe-like communities in 1.vegetation tier	2,000	10	50-100*)	-˚)	-	-
Steppe-like communities in 2.- 3. vegetation tier	2,000	10	2,000	-˚)	-	-

*) 50 m by built up or paved area, 80 m by arable land, 100 by other cultures
**) 100 m by built up area, 150 m by arable land, 200 m by other cultures
˚) do not occur in the scale of regional significance

attacks lack of possibilities to assert the best ideas of their own... However, even the fact that these rules have been included into the law regulating the landscape planning and management as in Bohemia and Moravia as in Slovakia creates better conditions for the environment policy and nature protection and do not exclude later corrections.

The theoretical basis for development and realization of the concept of TSES is the Zlatnik´s theory of the type of geobiocoen (Raušer & Zlatnik, 1966; Zlatnik, 1976). The type of geobiocen, is a reconstructive phytocoenological unit including all natural ecosystems (geobiocoenoses) bound to a type of permanent abiotic conditions together with all their developmental stages and man-disturbed communities (geobiocenoids) or artificial

Table 7. An estimate of a semiquantitative significance scale of actual vegetation formations for the landscape ecological stability (0 - without significance, 1 - very, 2 - little significance , 3 - intermediate, 4 high, 5 extraordinarily high significance) used in building up of TSES in the Czechoslovakia.

Actual vegetation	Classification	Score	Characteristics
Fields	arable land	1	every year intensively used
Vineyards	a - small areas	2	in narrow strips or terraces
	b - large areas	1	extensive vineards on arable land
Meadows, pastures	a - natural	5	alpine, montane
	b - seminatural	4	extensive, with protected plant species
	c- semicultural	3	high proportion of naturally growing plants
	d - cultural	2	intensively cultivated grassland
Orchards	a - small	3	with permanent herbage stratum
	b - large	2	with permanent herbage stratum
	c - large	1	herbage regularly stratum removed
Gardens	a - small	3	small gardens accompanied by semicultural vegetation
	b - alloted gardens	2	intensively used with week-end houses
Fallows	a - seminatural	4	abandoned fields, stone and send mines with advanced spontaneous succession
	b - semiruderal	3	abandoned areas with occurrence of ruderal plants and weeds
	c - ruderal	2	abandoned areas with predominance of ruderal plants and weeds
Wetlands	preserved	5	wetlands of any kind
Water surfaces	a - natural	5	bottom and banks with natural vegetation
	b- seminatural	4	modified bottom and banks with seminatural vegetation
	c - modified	3	stabilised banks or disturbed vegetation, influence of water pollution
	d - artificial I.	2	impermeably stabilised bottom and banks
	e - artificial II	1	strongly polluted, extremely degraded
Rocks	a - natural	5	-
	b - disturbed	3	-
Line formations	a - near-natural	4	without weeds and ruderal plants
	b - seminatural	3	weed and ruderal species little represented
	c- ruderal	2	weed and ruderal species predominate
Forets	a - natural or near-natural	5	natural species composition
	b - semicultural	4	admixed unoriginal trees, e. g. spruce in lower altitudes
	c - cultural	3	monocultures
Built up areas		0	continuously built up areas and areas with asphalt or concrete surface

communities. All secondary communities are expected to tend to return to an approximately natural state. The types of geobiocoens are classified into a three dimensional system of vegetation tiers (1. oak, 2. beech-oak, 3. oak beech, 4. beech in the Carpathians, oak-pine in the Hercynian mountain ranges, 5. fire-beech, 6. spruce-fire-beech, 7. spruce, 8. dwarf pine, 9. alpine meadows, 10. subnival), four throphic rows (A - acid, B - normal, C - nitrophilous, D - basic) and four hydric rows (dry, normal, humid, wet). The Zlatník´s phytocenological school was originally developed for the Carpathian forests, later generalised also for the forests in the Hercynian parts of Czechoslovakia (northwester Moravia, Bohemia), at present attamps at its generalization for non forest natural vegetation are in course in the Gregor Mendel Agricultural and Sylvicultural University of Brno.

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