APPLICATION OF THE CZECH METHODOLOGY OF BIOGEOGRAPHICAL LANDSCAPE DIFFERENTIATION IN GEOBIOCOENOLOGICAL CONCEPT – EXAMPLES FROM CUBA, TASMANIA AND YEMEN

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ABSTRACT

Within the area of Central Europe, and especially in the Czech Republic (and former Czechoslovakia), geobiocoenological landscape differentiation has been applied for more than 40 years to create a spatial model of the natural (potential) condition of geobiocoenoses in the landscape. Because long-term objective of geobiocoenology is to contribute to the creation of harmonic cultural landscape by gradual development of a comprehensive system of groundworks for sustainable landscape use, and as Mendel University experts work in various countries, adaptions of geobiocoenology were used also outside Europe, in tropical areas. Examples of such a work could be shown on islands such as Socotra (belonging politically to Yemen), Tasmania, and Cuba.

Key words: geobiocoenology, biogeography, landscape differentiation, sustainable development, ecological network, tropics

INTRODUCTION

Rudiments of geobiocoenology were worked out at the end of the 1930s by V.N. Sukachev who was one of the first researchers concerned with the relation of terms such as "geographical landscape" and "biogeocoenosis". He considered geobiocoenosis to be a part of the Earth surface on which the biocoenosis and the corresponding parts of atmosphere, lithosphere, hydrosphere, and pedosphere as well as their mutual relations remain homogeneous, thus constituting a uniform and internally conditioned complex (Sukachev, 1949; Sukachev & Dylis, 1964). The original Sukachev's term was altered by Zlatník (1975) to geobiocoenosis, the reason being an improper division of the central notion of biocoenosis.

Geobiocoenology is defined by Zlatník (1973) as a coenological discipline dealing with the unity of biocoenosis and ecotope, i.e. with geobiocoenosis. In this concept, geobiocoenology belongs in the sphere of natural sciences with its focal point dwelling in biology, and forms a necessary base of landscape ecology (Zlatník, 1975). Later he proposed to identify the ecologically-focused landscape surveying as geoecology, considering the terms of landscape ecology and geobiocoenology to be synonymous (Troll, 1970). Geobiocoenology deals with ecological relations at a level of landscape, integrating the knowledge of biology and geography – biogeography in particular – comprehended as a scientific discipline to study spatial bonds of organisms and their communities. This concept of geobiocoenology is in harmony with the trends of landscape ecology published by Forman & Godron (1993), Leser (1997) and Forman (1997) and their applications (Klopatek & Gardner, 1999; Schneider-Sliwa, Schaub & Gerold, 1999) closely relating to the need of integrated ecosystem and landscape management (Saunier & Meganck, 1995; Woodley, Kay & Francis, 1993).

Long-term objective of geobiocoenology is to contribute to the creation of harmonical cultural landscape by gradual development of a comprehensive system of groundworks for sustainable landscape use. Theoretical and methodological principles of geobiocoenological research into forests and landscape, gradually formulated by A. Zlatník in a range of monographs (Zlatník, 1970; 1973; 1975; 1976) were applied at drafting a biogeographical differentiation of landscape in geobiocoenological conception (Buček & Lacina, 1979; 1981; 1995; 2001; 2006). The methodological approach summarizes and consolidates modern conceptional approaches of biogeography, landscape ecology and geobiocoenology.

The first and most important step of this procedure is to develop a model of natural (potential) state of geobiocoenoses in the landscape, which is the task for geobiocoenological landscape typology. Geobiocoenological typology is based on application of the theory of geobiocoene types (Zlatník, 1975). Geobiocoene type is a system consisting of natural geobiocoenosis and all altered geobiocoenoses up to geobiocoenoids originating from this natural geobiocoenosis including developmental stages that may alternate within a segment of certain sustained ecological conditions. This indicates that the theory of geobiocoene types issues from a hypothetical unity of natural geobiocoenosis and changed geobiocoenoses up to geobiocoenoids, which have; however, developed on sites of the originally identical type of the natural geobiocoenosis.

Classification system of the geobiocoenological typology consists of primary and superstructural units. Primary units of geobiocoenological typology are groups of geobiocoene types. The groups associate geobiocoene types with similar permanent ecological conditions (bedrock, relief, climate, soils) on the basis of phytocoenological similarity. This means that individual groups of geobiocoene types are characterized by obviously different ecotope features conditioning variances in the species composition and in the productivity of both natural and human-altered biocoenoses. In landscape planning, the groups of geobiocoene types represent fundamental spatial frameworks to assess developmental trends and the state of the landscape. Within the framework of geobiocoene type groups we evaluate the intensity of anthropogenic impacts and the degree of ecological stability. Individual groups of geobiocoene types have various potentials for application of production and non-production landscape functions. This is why the groups of geobiocoene types are suitable spatial frameworks for landscape management planning.

Superstructural units of geobiocoenological typification of the landscape are altitudinal vegetation zones (AVZ) and ecological ranges (trophic and hydric). AVZ express the continuity of the sequence of vegetation differences with the sequence of differences in altitudinal and exposure climate (Vlčková *et al.*, 2015). Trophic ranges express conditions of the biota, given by soil nutrient contents and soil reaction. Hydric ranges express differences in the moisture regime of soils. Geobiocoenological classification system of the Czech Republic consist of 9 vegetation (altitudinal) zones, 8 trophic and intermediate ranges, 6 hydric ranges and 170 groups of geobiocoene types (Buček & Lacina, 2007).

The biogeographical landscape differentiation in geobiocoenological concept has been applied in regions with diverse natural and socio-economic conditions. In the Czech

Republic, it has also become a basis for the development of ecological networks and for landscape planning (Buček, 2009).

The aim of the article is to introduce the possibility of application the above mentioned methodology outside of Europe, especially in the tropic areas.

MATERIAL AND METHODS

Objective of the biogeographical differentiation of landscape in geobiocoenological concept is to develop a comprehensive set of fundamental documents for landscape and physical planning (Buček & Lacina, 1979; 1995; 1999; Míchal, 1994). Methodological procedure of biogeographical differentiation consists of several mutually linked parts based on the comparison of natural and actual state of geobiocoenoses in the landscape:

- biogeographical regionalization (individual division of the landscape);
- differentiation of the natural (potential) state of geobiocoenoses (typological classification of the landscape – geobiocoenological typification);
- differentiation of the actual state of geobiocoenoses (mapping of biotopes);
- evaluation of the degree of anthropogenic impact and ecological stability of geobiocoenoses;
- evaluation of the functional potential and significance of geobiocoenoses;
- construction of ecological network:
- definition of the skeleton of landscape ecological stability
- draft of the territorial system of landscape ecological stability
- definition of differentiated principles for the management of geobiocoenoses segments in the landscape and prognosis of their development.

Results of the geobiocoenological landscape typification enable development of a spatial model of the natural (potential) condition of geobiocoenoses in the landscape. In landscape planning, the model is an objective scientific basis to evaluate landscape potential, changes resulting from anthropogenic activities and to make a prognosis of the further development of the landscape. Fundamental spatial frameworks for the evaluation of developmental trends and landscape condition are groups of geobiocoene types.

Current condition of geobiocoenoses in the landscape is assessed according to their vegetation component. Differentiating the existing condition of geobiocoenoses in the landscape we use a formatively-physiognomical approach, defining biotope types as types of the present vegetation. Biotope mapping enables to differentiate surfaces with various types and intensities of anthropogenic impacts, with diverse species composition of biocoenoses and biocoenoids, and with various degrees of ecological stability (Maděra, 1996; 1998). Results of biotope mapping are needed in landscape planning especially for the definition of the skeleton of landscape ecological stability, design of biocentres, biocorridors and interactive elements as well as for the proposal of principles for the management of ecological network in the landscape. Biotope mapping provides important documents to assess urban planning development at optimizing environment quality.

Comparison of the potential and actually existing condition of geobiocoenoses within the groups of geobiocoene types allows to classify the intensity of anthropogenic impact and the degree of ecological stability. The classification scale of anthropogenic impact intensity expresses the measure to which the actual biocoenoses vary from the potential (natural) condition. Spatial framework of the classification are groups of geobiocoene types and within them the types of biotopes. Categorization according to the degree of anthropogenic impact classifies the geobiocoenoses into 6 categories: natural, semi-natural, near-natural, far-from-natural, foreign-to-nature and artificial (Löw *et al.*, 1995). Criterion for the classification is species composition and spatial structure of the vegetation component of geobiocoenoses. With respect to landscape ecological stability, the assessment of the importance of existing vegetation types (types of biotopes) is based on the amount of additional energy and nutrients required to maintain the existence of various biocoenoses in the cultural landscape. Classification makes use of a 6 - point scale, expressing the relative degree of ecological stability from very low up to the highest. The classification of anthropogenic impact and degree of ecological stability is used in the Czech Republic in landscape planning particularly for delineation of the skeleton of landscape ecological stability.

The relative scale of values helps to determine a possibility of applying various commercial and non-producing functions important for the functioning of cultural landscape. Functions usually assessed are those of agricultural and forest production, water management, soil protection, recreation and gene-pool significance. Groups of geobiocoene types are subjected to the assessment of their functional potential which is to express the maximum possible application of the respective functions. Biotope types are subjected to the assessment of their functional significance which is to express the possibility of actual application of the respective functions in the contemporary landscape. The comparison of potential and actual functional types allows landscape planning to evaluate suitability of the present landscape use.

Ecological network in the landscape consists of all existing and proposed relatively ecologically stable segments which contribute or will contribute to sustained biological diversity of the landscape (Buček & Lacina, 1996; Buček *et al.*, 1996). First step to construct a ecological network is to delineate the skeleton of landscape ecological stability, formed by ecologically significant landscape segments currently existing. Basis for the delineation is geobiocoenological typification of landscape and assessment of the current condition of geobiocoenoses. Unlike the skeleton of ecological stability, the territorial systems of ecological stability consist of both, the existing and the proposed parts. A territorial system of landscape ecological stability is a mutually integrated complex of natural and changed – though near-natural ecosystems, which maintain a natural stability. It is formed of ecologically significant landscape segments, purposefully distributed on the basis of functional and spatial criteria. It is, therefore, an optimally functioning system of biocentres, biocorridors and interactive elements. Geobiocoenological data are contained in four of five fundamental criteria for planning territorial systems; this indicates that they are necessary for the detection of diversity of potential natural ecosystems and biota’s spatial relations within the landscape, for planning spatial parameters and for the evaluation of landscape current condition. The fifth criterion are social limitations and territorial planning.

RESULTS

Socotra (Republic of Yemen)

The island has an area of about 3600 km^2, maximum altitude is 1540 m a.s.l. and is located some 230 km eastwards from Africa (Indian Ocean, Aden gulf) in arid tropical climate zone (Scholte & De Geest, 2010). It is of an elongated shape with length 130 km and maximum width of 42 km. Socotra belongs to the Africotropical biogeographical realm, Somalian biogeographical province (Udvardy, 1975).

1. AVZ: metrhel (planar): Altitude: 0–100 (150) m, coastal plains and flat uplands with hot and dry climate. Annual temperature 27°C, precipitation less than 200 mm, without permanent watercourses, water flows only episodically in rain season. Typical trees are *Euphorbia arbuscula, Dendrosicyos socotrana, Commiphora ornifolia* and *Maerua angolensis*.
2. AVZ: colinne, emhar: Altitude: (50)100–500(600) m, Rolling uplands and highlands with low precipitation, sub-arid climate. Temperature about 24°C, precipitation about 400 mm. Watercourses with water mainly in the rain season. Deciduous woodlands and succulent shrublands mostly with frankincense trees – *Boswellia ameero, B. elongata, B. dioscoridis, Commiphora ornifolia, C. planifrons, C. socotrana*. Often other emergent trees – *Sterculia africana, Lannea transulta* and *Tamarindus indica*. In the succulent shrubland *Adenium obesum* is common.
3. AVZ: submontane, ariob. Altitude: (400)500–800(900) m. Limestone plateaus and rolling highlands, relatively humid climate, influence of horizontal precipitation, temperature about 22°C, precipitation probably about 600 mm. Permanent watercourses. Vegetation: semi-deciduous forests and woodlands with optimum conditions for *Dracaena cinnabari*, shrublands with *Buxanthus pedicellatus*. Epilithic and epiphytic lichens are present.
4. AVZ: montane, dagash. Altitude: 800–1200 (1300) m. Granite mountains and highest parts of a limestone plateaus with humid climate, high precipitation, influence of dew and mist. Temperature about 20°C, precipitation 900-1000 mm including horizontal. Permanent outflow in watercourses, spring area of main brooks. Vegetation: evergreen forests and woodlands with *Dracaena cinnabari, Euphorbia socotrana, Euclea divinorum*, shrub layer with *Cephalocroton socotranus, Allophyllus rubifolius, Croton sulcifructus, Cocculus balfourii, Euryops arabicus*. Dense cover of epilithic and epiphytic lichens.
5. AVZ: alto-montane, azabzabahan. Altitude: 1200–1500 m. Peak parts of the granite mountains with humid climate, high precipitation and influence of horizontal precipitation. Temperature under 20°C, precipitation more than 1000 mm with important horizontal precipitation inflow. Spring area of watercourses. Evergreen forests and shrublands, and dwarf cushion vegetation on the rocks. *Dracaena cinnabari, Pittosporum viridiflorum, Spiniluma discolor, Euphorbia socotrana*; shrubs: *Thamnosma socotrana, Croton sulcifructus, Hypericum scopulorum, Coelocarpum hagghiriense* and *Euryops arabicus* are typical. Dense cover of lichens.

<u>Hydric ranges - Socotra (5 HR)</u>

1. dry HR - on cliffs, slopes, rocks, sand dunes etc. with very quick runoff, strong evaporation or quick infiltration; vegetation sporadic, scarce; presence of succulents.
2. limited HR - on shallow soils on steep slopes, usually influenced by sun or wind desiccation, the growth of woody plants is limited, presence of succulents.
3. normal HR - on deeper soils without quick runoff or infiltration, atmospheric precipitation is utilised by plants for evapotranspiration.
4. humid HR - rhizosphere is periodically or permanently influenced by additional groundwater, present usually in wadis in river valleys, around springs and permanent watercourses.

5. wet HR - permanently waterlogged soils, drying only on surface even in dry periods; on Socotra only around coastal platforms influenced by salted groundwater.

Trophic ranges – Socotra 5 TR and 3 IR

D – bazic: Alkalic litic soils on limestone and karren fields, soils are only slightly developed. Trees: *Dracaena cinnabari*, various frankincense trees i.e. *Boswellia dioscorides*, *B. bullata*, *B. nana*, *B. popoviana*.

BD – mesotrophic-bazic: Neutral to slightly alkalic soils (pH > 6.5), very well reserved soils on limestone substrates and other calcic sediments, on basalt and loess. This trophic range dominates on most of island area.

C – nitrophilous: Very rich soils in mineral supply, high content of nitrogen, on transit-accumulation and accumulation shapes of relief, mainly on slope debris. Presence of nitrophilous bio-indicators, i.e. *Dioscorea lanata*, *Ledebouria grandifolia*, *Trichodesma scotii*, centre of presence of trees: *Sterculia africana* var. *socotrana* and *Lannea transulta*.

CD – nitrophilous-bazic: very well saturated soils with higher nitrogen supply on slope debris on limestone

BC – mesotrophic-nitrophilous: Present only on limited area of mountain slope debris on granite substrate.

B – meso-trophic: Soils well supplied with minerals, slightly acid (pH 5.5-6.5), present mainly on igneous rocks with high supply of alkaline minerals.

A – oligo-trophic: still not developed soils on sand dunes on sea coast, substrate is often alkalic or enriched by salt. Typical vegetation: *Tamarix nilotica* and *Acacia edgeworthii*.

S – salty: Alkaline soils with high salt supply, mainly on sea coast and coastal plains with influence of sea water. Vegetation halophitic: *Limonium socotranum*, *Limonium paulayanum*, *Atriplex grifithii*, *Atriplex farinosa* and *Zygophyllum decumbens*, trees: *Avicennia marina*.

The system of basic units (GGT) was published in detail in papers Habrova & Bucek (2010) and Kral *et al*. (2010).

The system and characteristic of biotops of Socotra Island was published in detail by Habrova & Bucek (2013).

The skeleton of ecological landscape stability was delimitated by comparison of potential and actual state of the landscape. The results are used especially in the establishment of new plantation of different function (biocenters, home gardens, research plantation, etc.) to use appropriate tree species for site natural condition (Buček *et al*., 2003). Four bigger (0,25-1 ha) local biocentres have been established to protect endemic tree populations of *Commiphora ornifolia* (Quareh), *Dracaena cinnabari* (Shibehon), *Boswellia socotrana* (Galelhan) and *Boswellia elongata* and other trees (Homhil-Leeyeh). Other, approximately 180 usually smaller biocentres in home-gardens were established during Czech project activities until end of 2014 around the entire island.

Fig. 1: Altitudinal vegetation zones of Soqotra

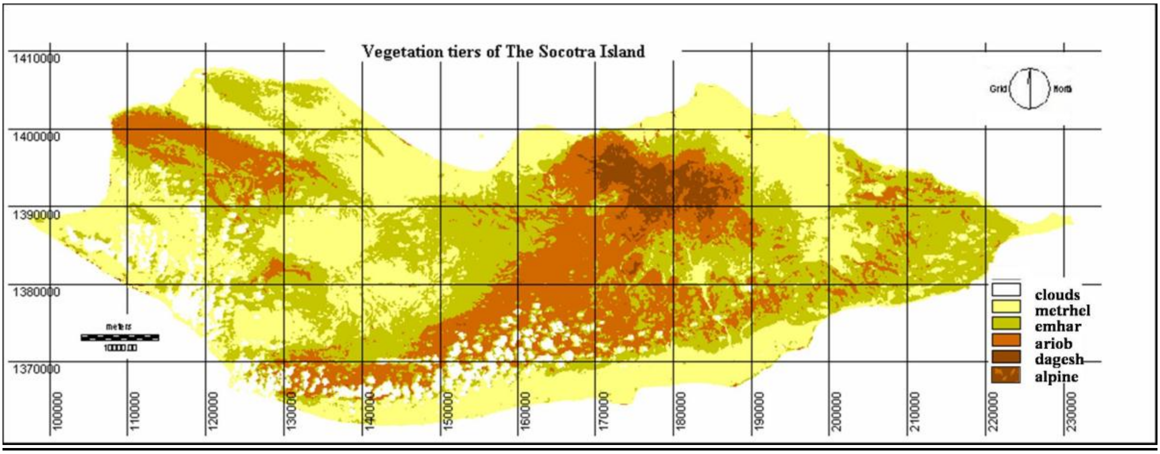
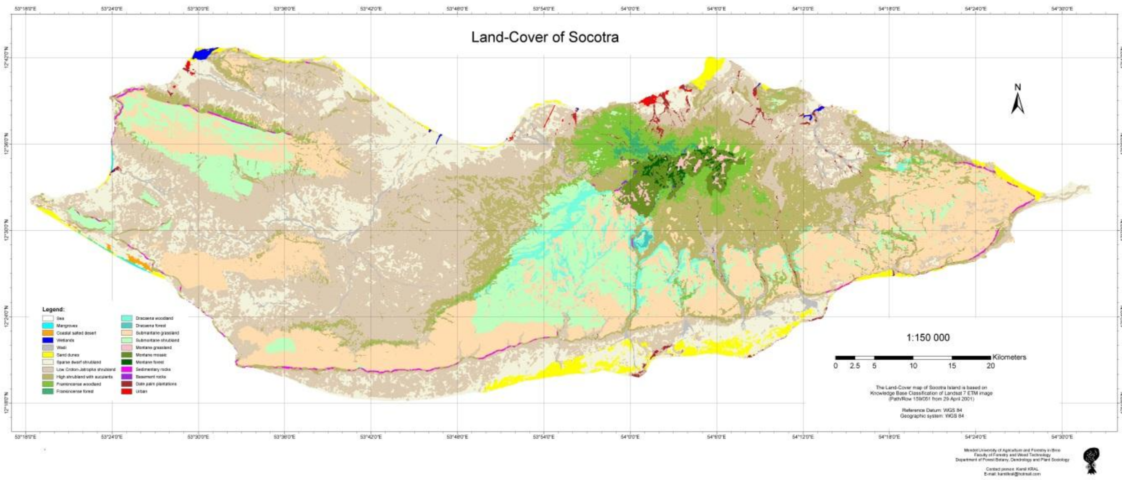


Fig. 2: Biotope (Landcover) map of Socotra (Kral & Pavlis, 2006)



Tasmania

The island area is about 68,800 km^2, maximum altitude 1617 m a.s.l., and it is located some 200 km southwards from Australia in cold oceanic climate (Indian Ocean, Tassman Sea, Bass strait). It has a slightly cordial shape. Tasmania belongs to the Australian biogeographical realm, Tasmanian biogeographical province (Udvardy, 1975).

The superstructural units of geobiocoenological typification of the Tasmanian landscape were proposed and characterised by Modrý (1999) in his thesis.

Altitudinal vegetation zones – Tasmania 7 AVZ

1. AVZ, 0–200 m a.s.l., forests of *Eucalyptus globulus,* on west coast *E. nitida,* on more rich soils high production ability;
2. AVZ, 200–400 m a.s.l. Domination of *E. obliqua* on drier sites and *E. regnans* on more humid sites. The most productive forests on Tasmania;
3. AVZ, 400–600 m a.s.l. Dominates *E. delegatensis* with undergrowth of *Acacia melanoxylon, A. dealbata* and other species (*Atherosperma moschatum*, *Eucryphia lucida*);
4. AVZ, 600–900 m a.s.l. Forests of *E. delegatensis*. They vary by absence of *Atherosperma moschatum* and *Eucryphia lucida* is replaced by close species *E. milliganii*.
5. AVZ, 900–1200 m a.s.l. Forests of *Eucalyptus coccifera* or *E. gunnii*. In higher parts, forests are represented by dwarf forms.
6. AVZ, 1200–1400 m a.s.l. Sub-alpine vegetation of non-forest form. Woods of dwarf form of *E. coccifera* and *E. archeri*, on places aside of alpine meadows *E. vernicosa*. On open sites very dense undergrowth of *Richea scoparia*.
7. AVZ, 1400+ m a.s.l. Alpine zone with low density presence of *Eucalyptus vernicosa*.

Hydric ranges (7 HR)

1 Dry HR - Present principally in the East part of Tasmania in lower parts. Climax – dry *Eucalyptus* forests. Frequent fires.

2 Normal HR - Precipitation with winter maximum, not less than 50 mm/month. Around the whole island in middle parts.

3 Humid HR - Precipitation with winter maximum, not less than 50 mm/month. Present principally in the West part of Tasmania and in higher parts of East. Climax – temperate rain forests. Fires less frequent.

4 Limited HR – on substrates with high water outflow and with higher drying out. It might be also a transit between dry and normal range. Annual precipitation 1000-1500 mm, rain distribution is uneven with summer dry period (< 50 mm/month), very frequent fires.

5 Gley HR – stagnation of water in soil profile in certain periods of the year, present mosaically around the whole island in depressions and in river valleys.

6 Peaty HR – localities with high precipitations in west half of the island. Soils continuously waterlogged. Fires are rare.

7 Wet HR with flowing water – aside smaller and bigger permanent rivers. Soils are saturated by slowly flowing water, water regime is not generally relying on precipitation, rivers in Tasmania have permanent watercourses.

Trophic ranges – Tasmania 2 TR

There are wide spectra of soils – from acid bogs to rich soils on basalt substrates. In SW area, often very acid peaty soils or acid cambisols are typical. Richer soils are present in northern, central and eastern Tasmania on alkaline rocks. In eastern part podzols are present on sandstones.

The most common soils are cambisols, luvisols and podzols.

With respect to absence of detail information about soils, only two trophic ranges were delimited:

Rich range (B): soils on basalt, limestone, dolomite and alluvial soils (ranges B, C and D according to Zlatnik, 1976).

Poor range (A): soils on sandstone, granite and quartzite (range A according to Zlatnik, 1976).

Cuba

Cuba is an archipelago of islands, located in the northern Caribbean Sea at the confluence with the Gulf of Mexico and the Atlantic Ocean. The climate is tropical, influenced by moderate trade winds. The Cuban archipelago has an area of 110,922 km^2. Main island Isla de Cuba has an area of 105,007 km^2 and maximum altitude of 1,972 m a.s.l. It has an elongated shape with length of 1,250 km and width of 31–191 km. Cuba belongs to the Neotropical biogeographical realm, Cuban biogeographical province (Udvardy, 1975).

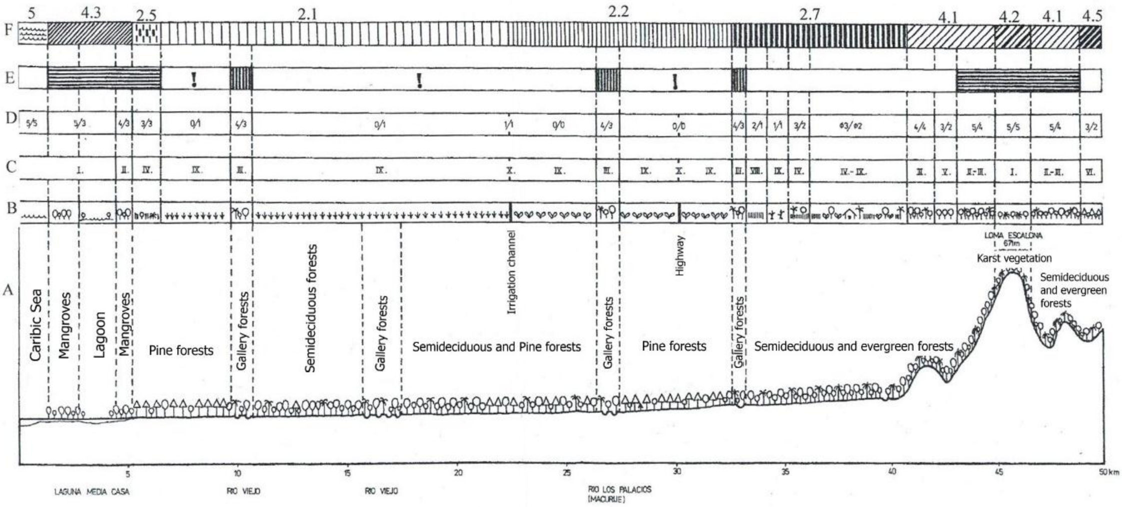
Some of the principles of biogeographic differentiation of the landscape were applied in the construction a set of maps of the environment in the new National Atlas of Cuba (Nuevo Atlas Nacional de Cuba, La Habana, 1989). Methods of creating territorial systems of ecological stability were applied for evaluating the spatial maintenance of ecological stability and for design of ecological network of Cuba (Buček & Lacina, 1983; Buček *et al.,* 1985; Buček, 1989a).

A coefficient of ecological stability expresses the ratio of environmentally relatively stable, versus unstable land-use categories in a given territory; for its evaluation, a wider background of land conditions to ensure the ecological stability of Cuba has been taken into account. The coefficient of ecological stability in Cuba decreased from 10.52 to 2.76 between 1852 and 1985. Variations in the values of the coefficient of ecological stability in different Cuban provinces were presented in the map of Buček (1989b). The lowest value reached this ratio in the province of Ciudad de la Habana, low values (1.0-1.9) were in the provinces of Ciego de Avilla, Cienfuegos, Las Tunas, Villa Clara and La Habana. Mean values of the coefficient of ecological stability (2.0 to 2.9) were recorded in the provinces of Sancti Spíritus, Holguín, Granma and Camagüey, high values (3.0 to 9.9) in the provinces of Matanzas, Santiago de Cuba, Pinar del Río and Guantánamo. The highest value (69.9) achieved a coefficient of ecological stability on the island of Isla de Juventud.

Available information about the structure, spatial parameters and biogeographical position of 187 declared or proposed protected areas were analyzed for creation of an ecological network of Cuba. Biogeographical significance of each area - from local significance to biosphere significance - was determined based on the evaluation of spatial parameters and of representativeness. As a basis for determining the biogeographical significance, the classification of phytogeographical regions of Cuba (Samek, 1973) and a map of potential natural vegetation of Cuba (Borhidi & Muniz, 1980) had been taken. On the biospheric level, seven biocentres - Sierra del Rosario, Turquino, Sierra del Infierno, Jaguaní, Pico Potrerillo, Los Indios and Santo Tomas - represent the richness of the Cuban countryside; other 16 biocentres are important provincially (Viňales, Sumidero, Cajálbana, Las Salinas, Toscano, El Palmar, Boca del Cauto, Piloto, Sierra del Cristal, Tacre, Cupeyal del Norte, Pico Galán, Imías, Baitiquirí, Cayo Coco, Cayo Romano and Cayo Paredón Grande). For delimitation a supra-regional biocentres, at least one representative area has been found in each phytogeographical region. Proposal of ecological network was presented in a separate map of the National Atlas of Cuba "Protected nature areas and their evaluation as bio-centers" (Martinez & Bucek, 1989).

Using the same method as in the Czech Republic, territorial system of ecological stability for the model area of Los Palacios, southwest of Havana, and of the island Isla de la Juventud (Lacina *et al.*, 1989; Lacina *et al.*, 1992) has been developed in detail. Especially model area of Los Palacios was very interesting during development of territorial system of ecological stability because this area reaches from the Caribbean Sea in the south with riparian lagoons and mangroves, through extensive pastures and plantations of root crops, sugar cane and rice, until harmonic agriculture-forest landscape in the Sierra del Rosario in the north (Fig. 3).

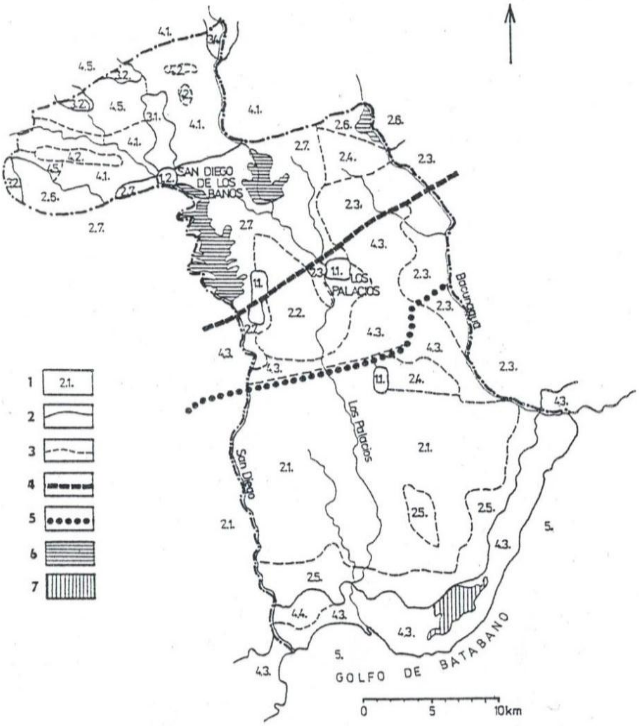
Fig. 3: Biogeographical cross-section of the Los Palacios county (Lacina, 1989)



A – natural state of the vegetation cover
B – actual state of the vegetation cover
C – differentiation by the intensity of anthropic influence (I. – original, II. – natural, III. – semi-natural, IV. – conditionally semi-natural, V. – near -natural, VI. – conditionally far from natural, VII. – conditionally near-natural, VIII. – far from natural, IX. – foreign to natural, X. – artificial)
D – degree of ecological stability/significance for gene-pool protection
E – ecologically significant landscape segments (horizontal hatching – plane ESLS, vertical hatching – line ESLS, ! – extremely inadequate land-use)
F – types of the contemporary landscape (2.1 – fields with a prevalence of irrigated rice plantations a plain, 2.2 – fields with prevalence of root-crops plantations in a plain and on flat hilly land with river terraces, 2.5 – pastures with a prevalence of non-cultivated pastures and post-agrarian lands with shrubs and swamps in a plain, 2.7 – varied mosaic of agricultural cultures on small areas and scattered woody vegetation around dispersed settlements in a flat hilly land and highland, 4.1 – semi-deciduous and evergreen forests in mountains, 4.2 – vegetation of isolated karst cones, 4.3 – mangrove, 4.5 – pine forests in the shaly part of the mountains, 5 – sea

The area was differentiated into 6 units of natural (potential) vegetation (mangroves, gallery forests around rivers, pine forests on slates, semi-evergreen forests, evergreen forests, scrub vegetation of mogotes) and 27 types of actual vegetation (including hydrobiocoenoses) (Fig. 4).

Fig. 4: Map of contemporary landscape types of the Los Palacios county (Lacina, 1989)



1 – numerical designation of the subtype of contemporaneous landscape (numbering is identical with numbering in the text)
2 – borders of the type of contemporaneous landscape
3 – borders of the subtype of contemporaneous landscape
4 – motorway
5 – route of the transversal irrigation canal
6 – water reservoirs
7 – lagoons

The territory of the municipio Los Palacios was differentiated in following types and subtypes of contemporary landscape:

1 Urbanized landscape:

with a low share of permanent vegetation in plains (0)

with a high share of permanent vegetation in hilly lands (1)

2 Agricultural landscape

2.1 fields with a prevalence of rice plantations with a network of irrigation ditches in a plain (0)

2.2 fields with prevalence of vegetable and root-crops plantations on slightly elevated river terraces in a plain (0)

2.3 fields with the prevalence of sugar-cane plantations in a plain and flat hilly land (1)

2.4 pastures with a prevalence of cultivated pastures with irrigation ditches and remnants of park forests in a plain (2-3)

2.5 pastures with a prevalence of non-cultivated pastures and post-agrarian lands with shrubs and swamps in a plain (4)

2.6 pastures with a prevalence of non-cultivated pastures and with shrubs in a flat hilly land (4)

2.7 varied mosaic of agricultural cultures on small areas, non-cultivated pastures and post-agrarian lands in a flat hilly land (3)

3 Agricultural-forest landscape

3.1 mosaic of agricultural cultures on small areas, non-cultivated pastures and broadleaved forests at a mountain foot (4)

3.2 mosaic of agricultural cultures on small areas, non-cultivated pastures and pine forests at a mountain foot (4)

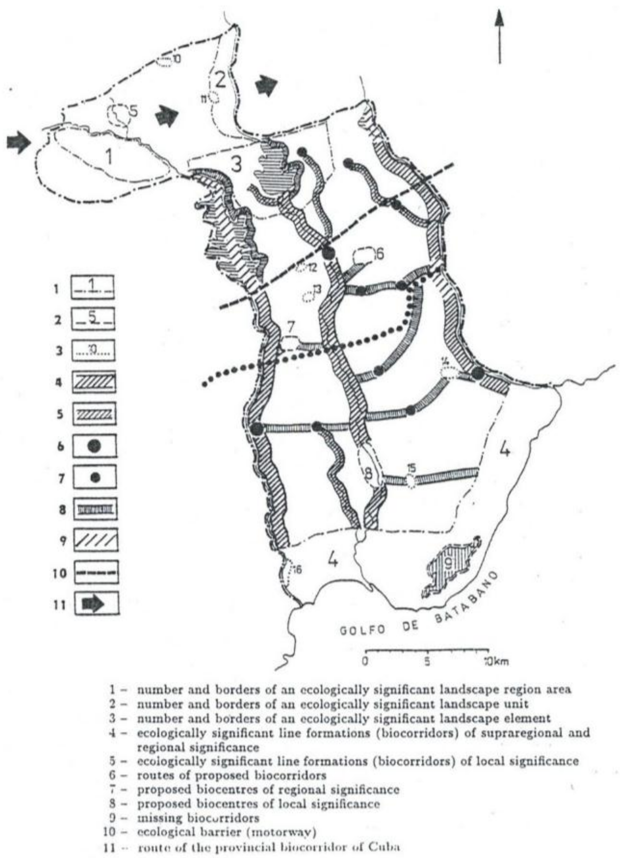
4 Forest landscape

semi-deciduous and evergreen forests in mountains (5)
vegetation of isolated karst cones (5)
mangrove (5)
plantations of Eucalyptus spp. and Casuarina equisetifolia on salted sand at the coast (3)
pine forests in the shaly part of the mountains (5)

Note: the numbers in the brackets express the degree of ecological stability (0-5) estimated on the basis of the share of permanent vegetation and the degree of anthropogenic effects.

In Los Palacios municipium, a skeleton of ecological stability, sufficient in extreme conditions of south coastal and northern mountainous areas, but completely inadequate in intensively agriculture-used central part, was delimited. Territorial system of ecological stability has been developed towards the south from supra-regional bio-corridor that runs in the W - E direction in the mountainous northern part of Cuba. As biocorridors of regional and local levels, mainly stripes of gallery forests along rivers, places and lanes of natural vegetation along the irrigation channels were used (Fig. 5).

Fig. 5: Skeleton of ecological stability of landscape of the municipium Los Palacios (Lacina, 1989)



DISCUSSION

The method of biogeographical landscape differentiation in geobiocoenological conception was established for purposes of ecological network planning and creation in the Czech Republic and Slovakia.

The concept of the creation of territorial systems of ecological stability applied in the Czech Republic (Buček *et al*., 2012; Mackovčín, 2000) corresponds with the latest landscape ecological knowledge and landscape planning procedures used abroad (see for example Jongman & Pungetti, 2004; Boitani *et al.*, 2011). Very similar concept is utilized in Slovakia (Ružičková & Šibl, 2000). In Germany, there is a network of biotopes /Biotopverbundsystem/ (Jedicke, 1994) created in the landscape. In the Netherlands, a national ecological network /Ecologische hoofdstructuur/ (Lammers & Zadelhof, 1996) is coming to existence. Some of the United States of America develop a network of biocorridors under the name of Greenways (Labaree, 1992; Smith & Helmund, 1993). In countries of the European Union, a pan-European ecological network is being gradually built within the EECONET (European Ecological Network) programme (Bennet, 1994; 2004; Nowicki *et al*., 1996; Jongman, 1998), consisting of a system of core areas – biocentres of European significance, interconnected by the means of biocorridors with adjacent zones of enhanced landscape management. Recently, the European Union has used phytosociological approach to define the system of habitats of European interest in the Habitats Directive (HD) 94/93/ECC (Rodwell *et al*., 2002). The concept of Green infrastructure came from America to Europe (Benedict & McMahon, 2006) as a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life for communities and people.

All mentioned methodological concepts have the same aim, the creation of ecological network for landscape biodiversity and stability maintenance, but different ways of reaching it.

The methods shown in the article used as key approach to comparison of natural and actual state of the landscape. The result of such comparison is evaluation of degree of anthropogenic influence or degree of naturalness. Zlatník (1975) in his theory of geobiocoene type defined this approach as one of the first ecologist. Ellenberg (1973, 1978) described six degrees of ecosystem naturalness, similarly Schlüter (1982) defined 10 degrees of vegetation naturalness.

According to Loidi (1994) naturalness should be understood as the degree of human influence in terms of distance to the climax in compliance with Zlatník´s theory. Machado (2004) gave the current view on naturalness in his thorough review.

For this purposes it is necessary to make the map of potential state of landscape. Usually, such maps are based on reconstruction of natural/potential vegetation units (e.g. Bohn *et al*., 2000/2003) that was published already by Tüxen (1956).

CONCLUSION

The method of biogeographical landscape differentiation in geobiocoenological conception was established in condition of temperate climate of central Europe, in Palaearctic biogeographical realm, biogeographic province middle European forest. The case studies shown in the article argue that this methodological approach is possible to use outside of Europe, especially in tropical areas. This approach was utilised in four out of eight biogeographical realms, defined by Udvardy (1975).

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