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Landscape dimensions – some theoretical remarks

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Abstract: The present study consists of three main parts. The first one discusses two opposed views on landscape dimensions. One, propounded by the "american" school and second, which is charakteristic for "european" school of landscape ecology. The second part presents the basic notions related to "geodesic" dimension of the landscape, found in relevant literature, which traditionally refers to its vertical (radial) and horizontal (lateral) dimensions. The former features diversification of geocomponents and is associated with such notions as "geomasses" and "geohorizons" , "lower and upper landscape borders", "lanndscape thickness" and "econ". The horizontal dimension is expressed with a landscape drawing (or, in a more recent approach) landscape configuration and composition. Essentially, these arbitrary terms pertain to three-dimensional space, which, as indicated by the author, necessitates a three-dimensional approach to the shapes of landscape units and their borders (Pietrzak, 2008, 2010).
Therefore in the third part the problem of landscape units considered as irregular three-dimensional solids is discussed. In author's opinion the previous approach to landscape units as flat figures is a far-fetched and groundless simplification. When we take into consideration time, without a doubt landscape is (at least) 4-dimensional "spacetime" phenomenon (structure). Its changeability is well captured with the notions of chorostructure (Pietrzak, 1998, 2010) and chronostructure (Pietrzak, 1998, 2010).

Key words: dimension, landscape structure, landscape units

Strictly speaking, the dimension (of a geometrical figure) equals the number of coordinates required to define any of its points. How many coordinates then are needed to define any part of a landscape and do universal dimension exists that would be applicable to all landscapes?
The literature proposes at least two diametrically opposed views on landscape dimensions1. One, propounded by the American school of landscape ecology, rests on the presumption that a landscape is "an area that is spatially heterogenous in at least one factor of interest" (Turner et al. 2001:7). Landscape, therefore, is defined with reference to a phenomenon recognized in studies, on the assumption that every organism has its own way of scaling, perceiving and using its environment, and thus no absolute (universal) landscape dimension exists and its scale depends rather on the environmental needs and requirements of a given organism (living being) and on all components of the mosaic of habitats or patches which the being finds important. Consequently, the landscapes of a bison, a hawk and a beetle differ from that of a human being (Pietrzak, 2010). There is no landscape as such, there are only landscapes of individual beings (Farina 2000, Farina, Belgrano 2004, Guillem et al. 2003). Hence, it is not possible to define the universal dimension of a landscape although each "individual" landscape comes with its own spatial and temporal characteristics.
The other view refers to the perception of a landscape as a phenomenon defined with relative precision in

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[1] Significant discrepancies between the European and American view of landscapes have also been noted by Lang and Blaschke (2007)

terms of scale and size (cf. Forman, Godron 1986 - "few kilometres in diameter") and classified between a cell, organism, population, community and ecosystem on the one hand, and a biome and a biosphere on the other. Clearly, this is the only approach which allows for defining (or at least attempting to define) the universal dimesions of a landscape. Seen in this manner, the multidimensional landscape having multiple characteristics will obviously change in space and time. Its changeability is well captured with the notions of chorostructure (Pietrzak 1998, 2010) and chronostructure (Pietrzak 1998, 2010), which refer to landscape dynamics and evolution as well as its development and history.

The functioning of a landscape (nano- and micro-changes) is rendered more precisely with the term ethostructure (Pietrzak 1998, 2010). Similarly, Soczawa (1975) distinguished changes taking place over the short term (functioning), middle-term (dynamics) and long-term (evolution).

Notably, the term landscape dimensions may be seen in a sense other than physical (geodesic). For instance Krzymowska-Kostrowicka (1997) ascribes to landscape the dimensions of:

- spatial configuration (or spatial differentiation),
- specialization (methods of use),
- centralization (the occurence of dominant systems),
- stabilization (sustainability and endurance of the natural world),
- standardization (the impact of binding social rules and legislative principles),
- anthropization (human impact),
- symbolization (cultural content).

Similarly, Zonneveld (1995) speaks of chorology, functions and changes (along with chronology and stability) as well as landscape assessments and development while Grodziński (1993) makes distinctions between the topical, process-based, chorological, factor-based and dynamic landscape ecology.

To return to the "geodesic" dimension of the landscape, the literature traditionally refers to its vertical (radial) and horizontal (lateral) dimensions2.

The former features diversification of geocomponents and is associated with such notions as geomasses and geo-horizons, lower and upper landscape borders and thickness. As of recently, Steinhardt et al. (2005), based on Löffler (2002), promoted the relatively unknown term of econ in reference to a specific part of a landscape having a distinctive structure of vertical landscape components. Econs are the smallest representative sections of a larger landscape unit used in landscape analysis of vertical structures and the processes occuring therein.

The horizontal structure is expressed with a landscape drawing (or, in a more recent approach: landscape configuration or composition), i.e. diversification (by number and type and spatial pattern and relationships) of landscape elements. The need to integrate the horizontal and vertical view of landscape space has also been pointed out by Mosimann (1984). Essentially, these arbitrary terms pertain to three-dimensional space, which, as indicated by the author, necessitates a three-dimensional approach to the shapes of landscape units and their borders (Pietrzak 2008, 2010). Of courses, in fact landscape is at least 4-dimensional 'spacetime" phenomenon (structure).

Landscape thickness refers to its vertical spread, i.e. the distance between its upper and lower limit (ceiling and floor). As rightfully noted by Przewoźniak (1991), its objective rendition is very complicated and ambiguous, mainly due to difficulties with defining marking the upper and lower borders of landscapes. Beruczaszwili (1986) placed the upper border of landscapes (for micro- i mezochoric levels) at the maximum height at which the substrate influences the atmosphere, which is very difficult to define given the great changeability of landscape states and weather conditions.

Kołomyc (1987) offers landscape unit dimensions for north-eastern Syberia by associating their areas and heights (thicknesses - M.P.) with taxonomic rank (tab. 1).

Herz et al. (1980), on the other hand, believe that the borders of the physiotopes which they consider to be the basic landscape units run at 1 meter above ground level and at 1.5 meters below its surface; hence, unit thickness would never exceed 2.5 meters. Przewoźniak (1991) placed the upper limit of shoreline landscapes at the top of their plant cover while putting the lower limit at the ground water level, however, he did not produce a

[2] Prieobrazeńskij et al. (1988) rightfully note that reliance on the vertical vs. horizontal distinction is a simplification of sorts as the two are closely interrelated and intertwined

map to depict them. These criteria are poorly suited for areas having no or only scarce plant covers and largely altered hydrographic conditions, as in urban landscapes. Note also that, under the former criterion, the bodies of humans entering certain landscape types (such as beaches) would partially protrude beyond their limits.

Tab. 1. Landscape unit thickness in north-eastern Syberia (Kołomyc, 1987)

Landscape unit	Thickness (km)
facies (site)	0,02 – 0,05
urotshisthe (stow)	0,1
mesochore	0,2
topochore	0,7
geochore	2,0

Hence, the author (Pietrzak, 1998) accepted the postulate by Beruczaszwili and Żuczkowa (1997) to set upper limits of landscapes at twice the height of plant cover during its peak growth or, should no plant cover exist, at the arbitrary height of 2 meters. Maps of upper and lower limits and thicknesses of landscapes based on such assumptions (probably such maps only available in Polish literature) made for the model area of Biskupice (central Wielkopolska Region) are provided in the author's previous work (Pietrzak, 1998). It should also be noted that in the organism (living-being)-centered concept of landscapes, the above determinations are largely verified to account for the parameters of specific being's habitats.

As mentioned earlier, the implications of prior discourses should be reflected in the study of shape of landscape units seen as a central physiognomic and diagnostic feature of a landscape. The existing methods, based on an isomorphic cartographic model (a landscape map) or (as is current practice) on a digital raster or vector image, precluded the application of a third vertical (radial) dimension. This makes them essentially incongruous with the concept of three-dimensional landscape and the above-mentioned notions of upper and lower border, landscape thickness, geomass, geohorizon and econ.

Without a doubt, landscape units are, geometric speaking, three-dimensional solids which are also most likely to be irregular. Therefore, the previous approach to landscape units as flat figures is a far-fetched and groundless simplification. If, therefore landscape is seen as:

(1) a specific level of nature differentiation, and

(2) a multidimensional (and multifeature) system having multiple attributes,

(3) composed of geocomponents and landscape units (geocomplexes), then it only follows that the proposed concepts be accepted.

Each landscape unit, perceived as a solid, thus comes with a lower base (floor) and an upper cap (ceiling) (so far referred to as upper and lower limits) and a side limit, whose top view superimposed on an area map has so far been identified with the borders of a given unit and its shape.

What are the theoretical and methodological implications of accepting the above concept?

The first key question to arise concerns a method for formally defining and presenting the shapes of landscape units which are irregular solids, which is quite a daunting task, also in geometric terms. The existing methods (such as borderline representation, representation with the so called borderline division relying on the so called primitives or voxels, as well as Béziera's curve modeling) are ambiguous and complex. They are also unavailable in software used to calculate the landscape metrics. The subsequent attempts to render the third dimension of landscape structure (such as Hoechstetter, Walz, 2006; Hoechstetter et al., 2006) do not apply to landscape units.

The most pertinent questions, however, relate to the landscape-ecological interpretation of landscape unit shapes as so defined and perceived, i.e.:

- Can landscape unit shapes continue to be seen as a vital (important) physiognomic and diagnostic feature of landscape units reflecting their state, quality and hemeroby?
- Are there specific landscape unit shapes (landscape solids) in various types of choro- and chronostructure?
- Do such shapes significantly influence landscape ethostructure?

Answers to these and other questions appear to constitute a key prequisite for the further development of the proposed concept and its full incorporation into the theory and methodology of landscape ecology.

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