

PHYTOINDICATION METHODS IN MAPS

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Introduction, goal and scope of the studies

One of the crucial problems of the contemporary world is to understand the changes in nature caused by multidirectional and diversified human activities. Ecological bioindication, especially phytoindication is just the method that enables to thoroughly analyse the structure and functioning of ecological systems.

Many empirical studies have proved that vegetation has a specific ability; it is overinformative and hence makes it possible to determine variables of the associated systems. To know the structure of plant cover, its spatial diversity, viability of some plant species means to be able to find out not only about the current state, but also about the process in these components of the environment which are ecologically vital to plant life.

Indicative botany uses indicator properties of individual plant species and communities to determine many parameters of natural environment quickly and cheaply.

A set of methods elaborated and verified for model areas of Białołęka Dworska and Lomianki (far Warsaw suburbs), where chosen so as to assess the state and changes in the vegetation itself and in its habitat. These are synoptic and analytic phytoindication methods. Moreover, so obtained results can be elaborated by cartographic methods and presented in maps at the scale appropriate to the goal of the studies.

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Phytoindicators

One of the synoptic indicators is Kostrowicki's (1972) complexity index (appendix 1). The application of this index facilitates to classify individual phytocoenoses to phytosociological units, and to determine the role of ecological and phytogeographical groups of plant species in these syntaxa. The index describes the degree of complexity of the phytocoenose structure, and hence it enables to express quantitatively the floristic, ecological and phytogeographical differentiation of the area under study. The application of this index is additionally advantageous because: 1) it indirectly indicates relative differences in primary productivity between phytocoenoses within a given spatial system (Fig. 1), 2) it helps to find out the degree of community transformation by man.

The index of information content can be applied to assess the degree of anthropization (Fig. 2), Roo-Zielińska E. 1982). For example, the area of Białołęka Dworska can be divided into two parts: the first has a very low (0 — 10 %, the second a very high (90 — 100 %) proportion of anthropophytes. A small proportion of intermediate phytocoenoses seems interesting. This phenomenon may be considered characteristic of mosaic spatial selection, conditioned by the type and intensity of anthropopressure.

Besides synoptic bioindication methods there are also some analytic phytoindication techniques, that of Ellenberg (1974) being one. It uses a bioindicative value of plant species (Ellenberg indices) to assess climatic and habitat conditions.

Climatic parameters: temperature index (T) and continentality index (K) are complementary. The first indicates a climatic optimum of species, while the second determines the boundaries thermal amplitude — winter hardness, first frosts, drought in summer. At microscale both indices do not vary (e.g. T for Białołęka Dworska), whereas at macroscale their variation can be considerable, adequate to the variation in climate.

Ellenberg phytoindication of habitat conditions concerns mainly substrate moisture, its acidity, and the content of available nitrogen.

Moisture index F expresses the ecological response of the species to substrate moisture within a growing season and enables us to determine the total plant requirements for it. In Białołęka Dworska F may range from dry, through mesic to moist habitats (Fig. 3).

Soil acidity maps (R index) help to assess biologically vital soil acidity on the basis of bioindicative properties of plant species and may indicate soils from very acid to plants to basic.

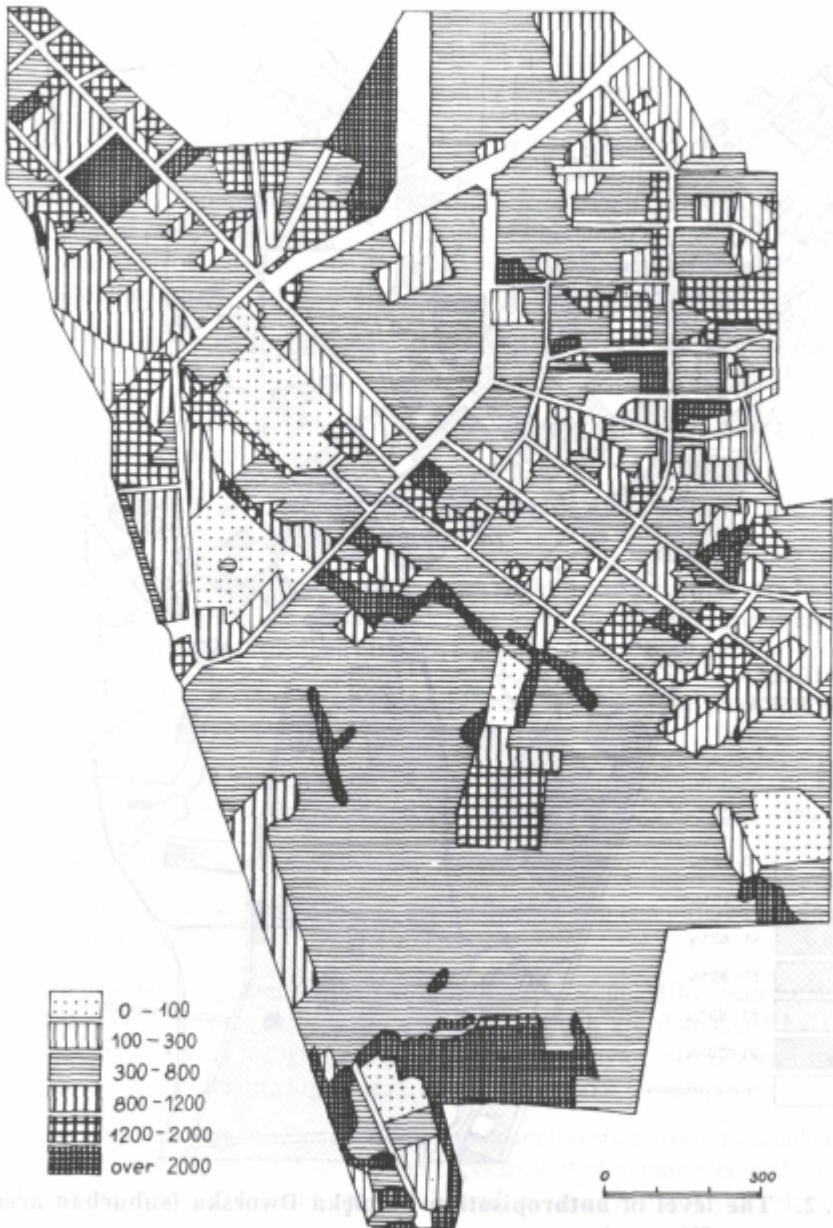


Fig. 1. Complexity index of herb layer structure.

Slika 1. Indeks kompleksnosti strukture zelišnega pokrova.

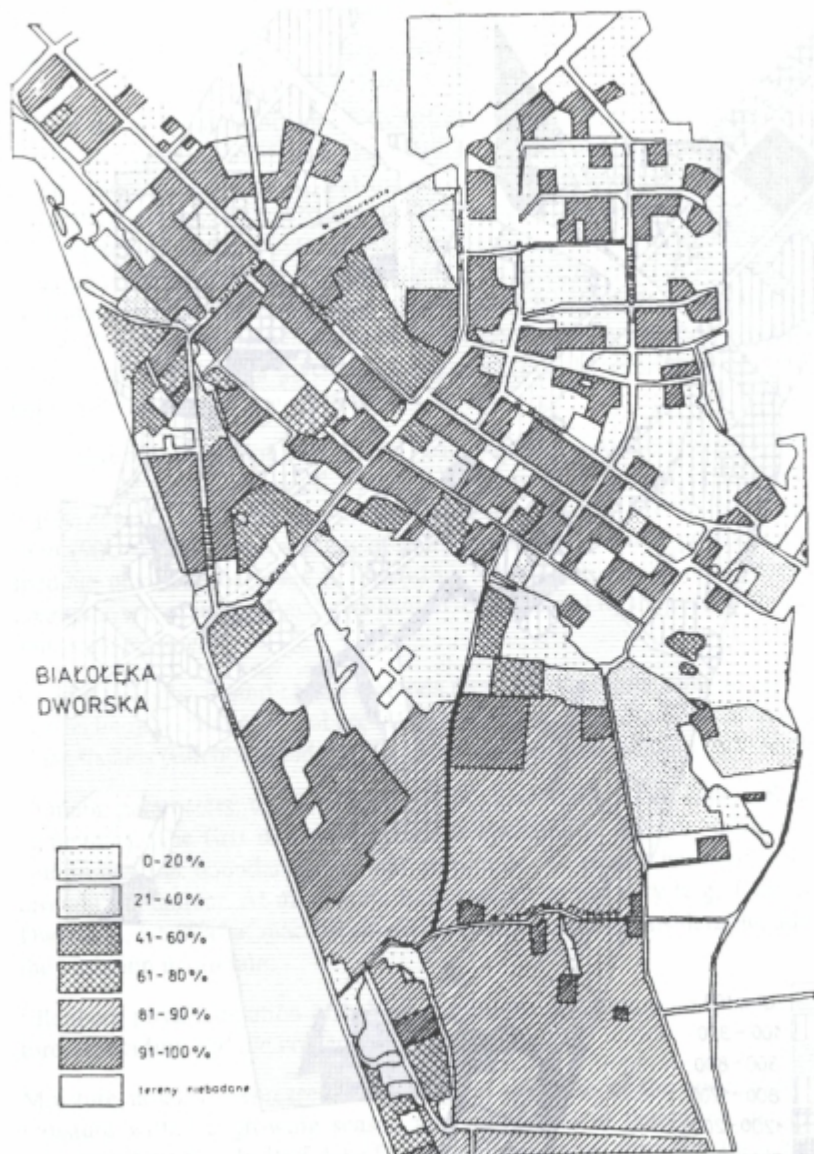


Fig. 2. The level of anthropisation Bałoteka Dworska (suburban area near Warsaw)

Slika 2. Raven antropizacije v Bałoteki Dworski (primestno območje Varšave).

N index expresses the ecological response of species to the content of available nitrogen in soil, from those ranges indicating its low content to showing its high content in the substrate.

The information on the above habitat properties obtained through vegetation analysis makes it possible to find out a distinct correlation with the composition and structure of plant communities. For example in Łomianki, the comparative spatial differentiation of real vegetation and of the habitat properties mentioned above has enabled, through phytoindication, to distinguish 6 ecological-habitat units:

- pine mixed, pine forests in dry, acid soils, with poor and medium nitrogen content,
- mixed oak-hornbeam forests on mesic, slightly acidic soils, with medium nitrogen content,
- arable fields with cereal, root and tuber crops on mesic soils, variable in their acidity and nitrogen content.

The first complexes of a larger area occupies slightly acid soils with very high and high nitrogen content. The second borders on forest communities and is confined to acid substrate with a medium nitrogen content,

- poplar-willow flood-plain forests in different developmental phases on moist, slightly acid or neutral soils, very rich in nitrogen,
- seminatural and anthropogenic meadow and pasture communities, on mesic, sometimes moist, slightly acid and neutral soils with high nitrogen content,
- alder-carrs and reedswamp communities on wet soils.

In Białołęka Dworska the study area can be divided into two different ecological-habitat units:

- the habitats of potentially mixed pine forests, occupied by psammophilous grasslands, moors, and *Nardus* grasslands, which are dominated by forest species with only a slight proportion of anthropophytes. Here, boreal species prevail. Substrates are highly acid, dry or mesic, poor in nitrogen,
- the habitats of potentially mixed oak-hornbeam forests, covered by arable fields with a high proportion of synanthropic species with their ranges being European or Euro-Asiatic. Substrates are slightly acid, moderately moist, rich in nitrogen.

The phytoindication analyses mentioned above can be summed-up and synthesized in a map of geobotanical valorization of Białołęka Dworska. It is worth stressing that the assessment of geobotanical and habitat conditions should be conducted on

the grounds of flora and vegetation. The following criteria were taken into account to make the map mentioned above:

- 1) the degree of complexity of vegetation structure — the highest is characteristic of all well-preserved forested areas (birch forests, pine and mixed pine forests, fragments of oak-hornbeam forests), and fertile psammophilous grasslands, in a mosaic with the former,
- 2) healthy conditions — they can be determined from typical community composition of species that secrete directly or indirectly via soil, chemical substances with phytotherapeutic or phytotoxic properties,
- 3) habitat elasticity i.e. their ability to transform. This parameter is determined from the number of substitute communities of a given potential community.

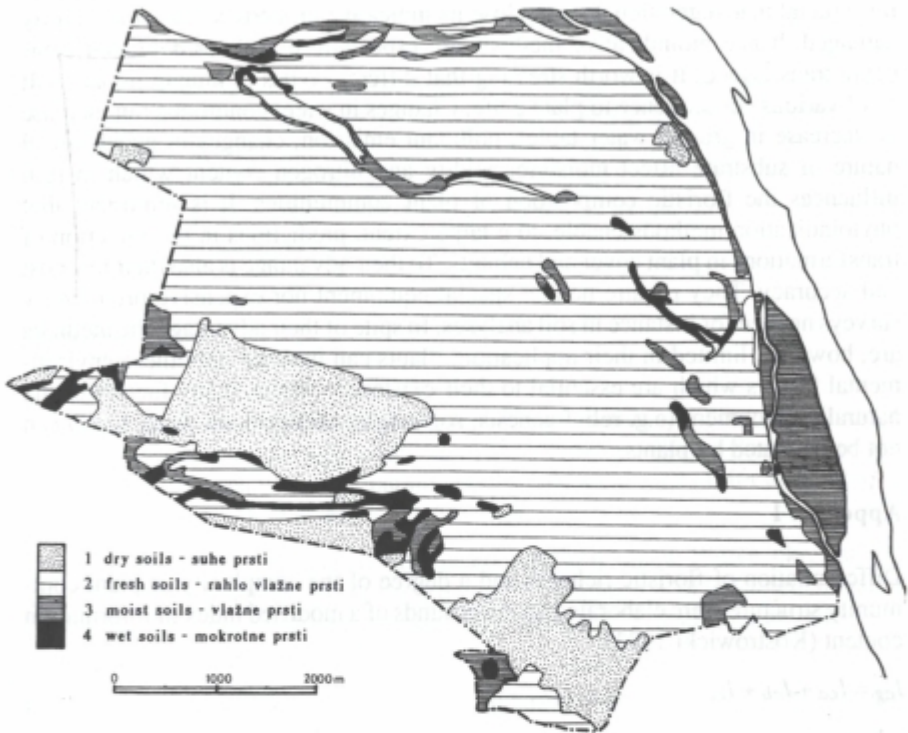
The map of geobotanical valorization seems to be useful in the assessment of the area by botanical-ecological criteria.

Methods of cartographic presentation of bioindication in maps

A number of cartographic methods are used to present the results of bioindication, such as: cartodiagram, cartiogram, techniques of ranges, isolines and points. It should be stressed that the sampling type and presentation scale determine the choice of appropriate method. The results of phytoindication analysis are presented through different cartographic techniques.

For detail and accuracy regarding the equal-area registration of phenomena, a classic sampling procedure is required. However, due to its high labour consumption it is applied only to small areas, such as Białołęka Dworska (300 ha). In these cases a cartogram is usually used (Fig. 1, 2). The map then presents a phenomenon intensity within small spatial units like: estates, farms, complexes of arable fields or forest divisions. Such maps exhibit high patchiness, and are difficult to generalize.

At medium scales (10 — 50,000) it is impossible to present bioindicators through the generalization of the class number. Qualitative generalization is also necessary to accentuate a picture typical of a given land use. At the same time artificial spatial units are transformed into natural ones. The method of mapping ranges is fairly common. It was also used in Lomianki near Warsaw (Fig. 3), and earlier by S. Borowiec (1972). The picture obtained is geographically ordained, while the map is clearly suggestive and easily comparable with others.



Evaluation of soils humidity in Łomianki commune (suburban area near Warsaw).

Slika 3. Vrednotenje vlažnosti prsti v občini Łomianki

The phytoindication method is often applied for selected areas e.g. small homogeneous vegetation patches (meadows, xerothermic grasslands, marshes, forests) where relives are recorded. Then point technique is mostly used, with the application of simple ribbon, circle of bar charts, where the center of a circle and the base of a bar are located at a place of areas. In the analyses based on phytoindication, isoline method is often used, especially at and in smaller scales, like in the assessment of the continentalism degree in oak-hornbeam forests of Poland (Degórski 1984).

At present, it is already obvious that each plant and plant community reflect their living conditions.

It is crucial that vegetation does not lose its indicative properties even if it is partly damaged, hence bioindicative methods are especially useful for degraded areas being transformed. It is worth stressing that different types of human impact will be of various consequence to plant life. Changes in water conditions (an increase or decrease in ground water table), pollutant emission, changes in geochemical nature of substrate affect moisture, acidity and nitrogen content which in turn influences the floristic composition of plant communities. It is important that phytosociological methods enable, to a large extent, predictions in the direction of transformations in plant cover and habitats. To their advantage is also their low cost and accuracy. They require neither special equipment nor expensive preliminary surveys needed for instance in soil analyses. In spite of their advantage the methods are, however, limited in their application. Plants can indicate only these environmental factors which are essential to their existence. Hence, many factors of the natural environment (e.g. relief genesis, soil origin, underground water level) can not be indicated by plants..

Appendix 1

Differentiation of floristic richness and a degree of the complexity of plant community structure were elaborated on the grounds of a modified index of information content (Kostrowicki 1972):

$$I_{cg} = I_{ca} + I_{cb} + I_{cc}$$

where:

I_{cg} — general (total) information content

I_{ca} — information content of tree layer

I_{cb} — information content of shrub layer

I_{cc} — information content of herb layer

For each layer indices were calculated according to the formula:

$$I_c = \frac{h [0.5 (s^2 + s)^{dom} \times c^{dom} + (s^{com} \times c^{com}) + (s^{acc} \times c^{acc})]}{100}$$

where:

h — mean layer height (in cm)

s — species number

c — total species cover

dom — dominant species with cover $\geq 5\%$

com — companions, species with cover $\geq 0.5\%$ and $\leq 5\%$

acc — accidental species with cover $\geq 0.1\%$ and $\leq 0.5\%$

The index directly describes the differentiation of vegetation structure, enables us to determine it qualitatively and to compare stands of a single or different phytocoenose types. It also indicates indirectly the relative differences in primary productivity between phytocoenoses of a single spatial complex. If other parameters are incorporated then the index also enables us to determine the degree of community transformation by man.

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Fitoindikacijske metode na kartah

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Povzetek

Eden izmed ključnih problemov sodobnega sveta je razumeti spremembe v naravi, ki jih povzročajo mnogovrstne in zelo različne človeške dejavnosti. Ekološka bioindikacija, še posebno fitoindikacija, je metoda, ki omogoča natančno analizo struktur in delovanja ekoloških sistemov.

Mnoge empirične študije so dokazale, da ima vegetacija specifično sposobnost, da je hiperinformativna, zato je omogoča določevanje variant združb in sistemov. Če poznamo rastlinsko odejo in njeno prostorsko razširjenost na eni ter življenjsko sposobnost nekaterih rastlinskih vrst na drugi strani, lahko ugotovimo ne samo sedanje stanje, ampak tudi tiste procese v sestavinah okolja, ki so ekološko bistvenega pomena za življenje rastlin.

Indikativna botanika uporablja specifične lastnosti posameznih rastlinskih vrst in združb, da lahko hitro in poceni določa parametre naravnega okolja.

Na območjih Białybłęka Dworska in Lomianki (oddaljeni varšavski predmestji), ki sta služili za model, smo izdelali in uporabili vrsto metod, s katerimi smo ugotavljali stanje in spremembe v vegetaciji in njenih rastiščnih pogojih. To so sinoptične in analitične fitoindikacijske metode. Tako dobljene rezultate lahko obdelamo s kartografskimi metodami in jih predstavimo na kartah v merilih, ki odgovarjajo namenu raziskav.

Eden izmed sinoptičnih indikatorjev je indeks kompleksnosti Kostrowickega (1972). Uporaba tega indeksa omogoča določanje posameznih fitocenoz v fitosocioloških enotah in s tem v zvezi določanje vloge ekoloških in fitogeografskih skupin različnih rastlinskih vrst. Ta indeks prikaže stopnjo kompleksnosti fitocenoznih struktur, zato torej lahko kvantitativno izrazi rastlinske, ekološke ter fitogeografske razlike na proučevanem območju. Uporaba tega indeksa ima to prednost, ker: 1) indirektno označuje relativne razlike v primarni produkciji med

fitocenozi znotraj danega prostorskega sistema (sl. 1), 2) .pomaga ugotoviti stopnjo transformacij, ki jih povzroča človek.

Poleg sinoptičnih bioindikacijskih metod so še druge analitične fitoindikacijske tehnike, npr. Ellenbergova (1974). Ta uporablja bioindikativno vrednost rastlinskih vrst (Ellenbergovi indeksi), s katero proučuje klimatske in rastiščne pogoje.

Vlažnostni indeks F izraža, kako posamezne vrste rastlin med rastjo ekološko odgovarjajo na minimalno vlago in omogoča določanje količine potrebne vlage za rastlino. Pri Białofęci Dworski odraža razpon F vrednosti od suhih, prehodnih, do vlažnih habitatov. (sl. 3).

Karte, ki prikazujejo kislost prsti (R indeks), pomagajo pri določanju biološko pomembne kislosti prsti na podlagi bioindikativnih lastnosti rastlinskih vrst. Na njih lahko razvrstimo prsti v razponu od zelo kislih za rastline do bazičnih.

N indeks izraža, kako se posamezne rastlinske vrste ekološko odzivajo na količino dušika v zemlji, od tistih, ki označujejo nizko prisotnost, do zelo visokih vrednosti.

Podatki o navedenih lastnostih rastišč, ki smo jih dobili z analizo vegetacije, omogočajo ugotoviti pomembno korelacijo s kompozicijo in zgradbo rastlinskih združb. Na karti geobotanične valorizacije območja Dworske omenjene fitoindikacijske analize povzamemo in sintetiziramo. Poudariti velja, da je ugotavljanje geobotaničnih in rastiščnih pogojev potrebno izpeljati na osnovi proučevanj vegetacije.

Za predstavitev bioindikacijskih rezultatov uporabljamo več kartografskih metod, n.pr.: kartogram, kartodiagram, ploskovne ponazoritve (obsega), izolinije in točko. Izbor območja in namen predstavitve določata izbiro ustrezne metode. Rezultate fitoindikacijskih analiz lahko predstavimo z različnimi kartografskimi tehnikami.

Klasični postopek je podrobno in natančno opazovanje ter opisovanje pojavov na enakih področjih. Vendar to zahteva ogromno dela in s zato lahko uporablja samo za manjša območja, kot n.pr. Pri Białofęci Dworski (300 ha). V teh primerih običajno uporabljamo kartogram. (sl. 1,2)

Pri srednjih merilih (10 — 50000) je nemogoče predstaviti bioindikatorje z generalizacijo števila razredov. Za ugotavljanje stanja o tipični izrabi proučevanega območja je potrebna tudi kvalitativna generalizacija. Istočasno se umetne prostorske enote spremenijo v naravne. Pri tem je najbolj uporabna ploskovna tehnika. Uporabljena je bila tudi pri proučitvi območja Lomianki blizu Varšave. (sl. 3)

Pogosto uporabljamo fitoindikacijsko metodo tudi za izbrana območja, n.pr. majhne predele s homogeno vegetacijo (travniki, kserotermičnimi pašniki, močvirja, gozdovi), kjer so označeni z znaki. Pri tem se največkrat uporablja tehnika s pikami,

pa tudi preprost linijski diagram krog ali stolpec, pri čemer sta center kroga in osnovna stolpca nameščena v sredino obravnavanega območja.

Če se pri izbiri oblik in vrst diagramov odločimo za krog ali stolpec, moramo pri izbiri vrste diagrama upoštevati tudi vrsto podatkov, ki jih želimo prikazati. Če želimo prikazati razmerja med posameznimi deli celote, je bolj primeren krog, če pa želimo prikazati spremembe v času, je bolj primeren stolpec.

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