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THE MAP OF LANDSCAPE USE

Optimization of ways of land use is a possibility to intensify agricultural production and raise the standard of living. Borderlines of various land use types and functions of the terrain depend on many factors; apart from natural conditions, they include economic and social factors. It is well known that the land use is decided by its location relative to markets, transportation issues and tradition. The land use pattern is due to ownership relations, though aesthetical aspects may be important, too. However, land use is most closely connected with natural potential. It is well known that in Europe forests have been preserved in poor habitats and that intensive agriculture is connected with fertile soils. Examples to illustrate this may be multiplied and the purpose of studying them depends on the accuracy of an analysis. When the analysis in sufficiently accurate, one can see conditions that have been unknown or suspected only intuitively. Then there is a possibility to distinguish areas that are used properly or improperly, treatment may be recommended to increase crops or changes in cultivation may be proposed that would permit a more effective way of land use.

The first map showing the dependence of use on landscape pattern was elaborated in the German Democratic Republic by a team headed by H. Richter and was published in that country's atlas on the scale of 1:750 000 as a map of landscape diagnosis (H. Richter, 1981). In the background of the groups of types of "natural space" (Naturraumtypen) were marked with designs, after a map of landscape division of the GDR (H. Richter, 1978). Onto the natural classification was then superimposed differentiated land use divided into 5 main complexes: settlement areas, areas of opencast exploration of natural resources, agricultural areas, forest complexes and areas of mixed agricultural-forest use. Such a map permits an analysis of land use within the borders of units existing in nature, that is geocomplexes. This fact should be stressed as this is the most proper procedure from the methodological viewpoint and it differs fundamentally from the widely applied analysis of land use within administrative

limits. The authors of the discussed map pay special attention to areas with mixed use, claiming that they can be an area of manoeuvre in development planning. Theoretically, only in such areas it is possible to change the use and substitute a mosaic of forests and fields with a more homogeneous contour.

The map of landscape diagnosis of the German Democratic Republic was published in connection with activities of an international working group established within the subject "Ecological foundations for planning of optimum landscape structures" (topic III-2 in the plan of scientific co-operation of CMEA countries). The group's task was to develop a uniform concept of a general scale map of landscape diagnosis. The procedure was discussed at a few international symposia (Potsdam, 1980; Halle, 1981; Płock, 1983). Representatives of the Warsaw Centre actively participated in the works and they elaborated, for instance, a typology of Poland's natural landscape (A. Richling, 1984) and analyzed the contents of general landscape maps published abroad (W. Lewandowski, A. Samsonowicz, 1981) which ended in an attempt to define the mutual relation of units distinguished on the maps (A. Richling, 1985). Studies were also made on the place of land use in the classification system of natural landscape (W. Lewandowski, K. Ostaszewska, 1983).

Works on the map were conducted in Poland on various scales. In accordance with decisions of the working group a few fragments of the country were elaborated on the scale of 1:500,000 as well as on the scale 1:100,000 with somewhat different assumptions. There are also trial analyses of natural conditions of land use on the basis of field mapping on accurate scales of 1:10,000 and 1:25,000. These are called landscape use maps. Landscape diagnosis is popularly understood in Poland as an examination including an evaluation. The above-mentioned works do not contain evaluations, therefore the term "landscape use" seems better than "landscape diagnosis".

Works towards drafting a map of landscape use of Poland on the scale of 1:500,000 started from a detailed classification of land use. The division applied by H. Richter was suited to the structure of agriculture in the GDR, where farmland is owned by the state. In Poland, where private land ownership is prevailing, farmland is much more dispersed and mosaic-like. As a result of discussions and many tests, grassland, as well as areas with a substantial share of orchards and plantations of vegetables and fruits, were additionally introducted. Also the number of mixed types was expanded. A full classification of land use for general landscape use map of Poland is as follows:

1. L Forest types (uniform forest complexes covering 75—80% of the area including afforestations, clearings and small glades < 3 km^2, including also small settlements, agricultural areas, recreation areas and small water reservoirs < 3 km^2;

2. R Agricultural areas (covered mainly with arable land 75—80% of the area, including also small settlements, orchards and gardens, small industrial plants as well as isolated forests and pastures < 3 km^2);
3. Z Grasslands $> 60\%$ of the area (mainly parmanent meadows and pastures as well as marshy grounds and swamps of the area > 3 km^2, including also small settlements and isolated agricultural areas and forests < 3 km^2).
4. Mixed types
4.1. R/L Mixed agricultural — forest areas (mosaic type of use, mostly agricultural, with a substantial share of dispersed forest areas, however not exceeding 3 km^2);
4.2. R/Z Mixed areas arable land — grasslands (mosaic type of use, mostly fields, with a substantial share of dispersed areas used as permanent meadows and pastures — most frequently in depressions and small valleys, whose area does not exceed 3 km^2);
4.3. L/Z Mixed areas forests — grasslands (mosaic type of use, including dispersed small forest areas < 3 km^2 as well as permanent grasslands, most often marshy grounds, swamps as well as wet meadows and pastures) occurring most frequently in valleys of big rivers;
5. S Orchards and plantations of fruits and vegetables (terrains with a substantial share of area — minimum 25—35% — covered by orchards and plantations of fruits and vegetables, with a share of areas covered by small settlements, small industrial plants as well as forests and agricultural areas < 3 km^2);
6. O Settlements and urban areas (towns and compact settlements, including also industrial plants not fitting the map's scale, transportation junctions, recreation-sports areas, parks, gardens and cemeteries);
7. P Mining-industrial areas (mostly opencast mines, large industrial plants, waste-heaps and dumping grounds as well as recultivated areas).

The experience also shows that it is necessary to seperate a mountaineous variety within the mixed types. The variety is characterized by an increased share of grasslands (mountain pastures) as well as by a very mosaic-like pattern of the natural environment.

An analysis of land use against a background of its landscape pattern was made within four areas located in various types of landscape and characterized by very differentiated types of land use and anthropogenic transformation of the environment. The areas were the following: Olsztyn Lake District, Voivodship of Płock, Częstochowa Upland, High Beskid with Babia Mount.

Within each of these areas, the above-mentioned categories of land use

were presented with different colours against a background of landscape kinds[1] marked with hachures.

The analysis of land use was made on the scale of 1:100,000 on the basis of topographic maps on the same scale or on more accurate scales. Principally, contours of areas above 3 km^2 were included, omitting smaller objects due to the assumed scale of the study. Afterwards, the map of use was mechanically diminished to the scale of 1:500,000 and an outline of types of the natural landscape was superimposed.

Apart from the above-mentioned elements, the map of landscape use contained markings of dunes, clear undercuts and edges as well as an approximate range of the impact of towns and industrial plants degrading the environment, mines, artificial water reservoirs, areas valuable for tourism and recreation as well as protected natural objects: national parks, landscape parks and reserves.

The map's legend does not contain detailed information on vegetation and climatic conditions. Typology of vegetation, particularly classification of its anthropogenic transformation, should be a significant supplement to the map's content. However, there are no sources containing the above data on a suitable scale for the territory of the whole country. Special field mapping is impossible due to practical reasons. One should also note that the supplementary table to the map of natural landscape typology of Poland contains information on types of meadow and forest vegetation existing within the limits of successive landscape varieties; also a few years ago J. Kondracki and J. Ostrowski designed a map of the synantropization of the environment in Poland on the scale of 1:2,000,000 (J. Kondracki, J. Ostrowski, 1980). The map presents the degree of synantropization within physico-geographical mezo-regions treated as basic fields. The following scale was applied: lowest, low, medium, high, very high and highest degree. A regional and quite sketchy treatment of the phenomenon makes it impossible to use the map for the needs of a landscape diagnosis map; however, it is a good supplementary material and may help planners in taking correct decisions.

Climate was omitted for other reasons. Attempts to make climatic characteristics for the separated units were unsuccessful. The only possibility was a verbal description making use of commonly known dependences between climate and other components of the natural environment. The scale of the map seems to be decisive. On more detailed scales methods to study topoclimates should be applied.

A black and white fragment of a map of the Płock voivodship (Fig. 1) is an example of the work the authors have done.

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[1] In the classification of Poland's natural landscape there are classes, sorts, kinds and variations of landscape.

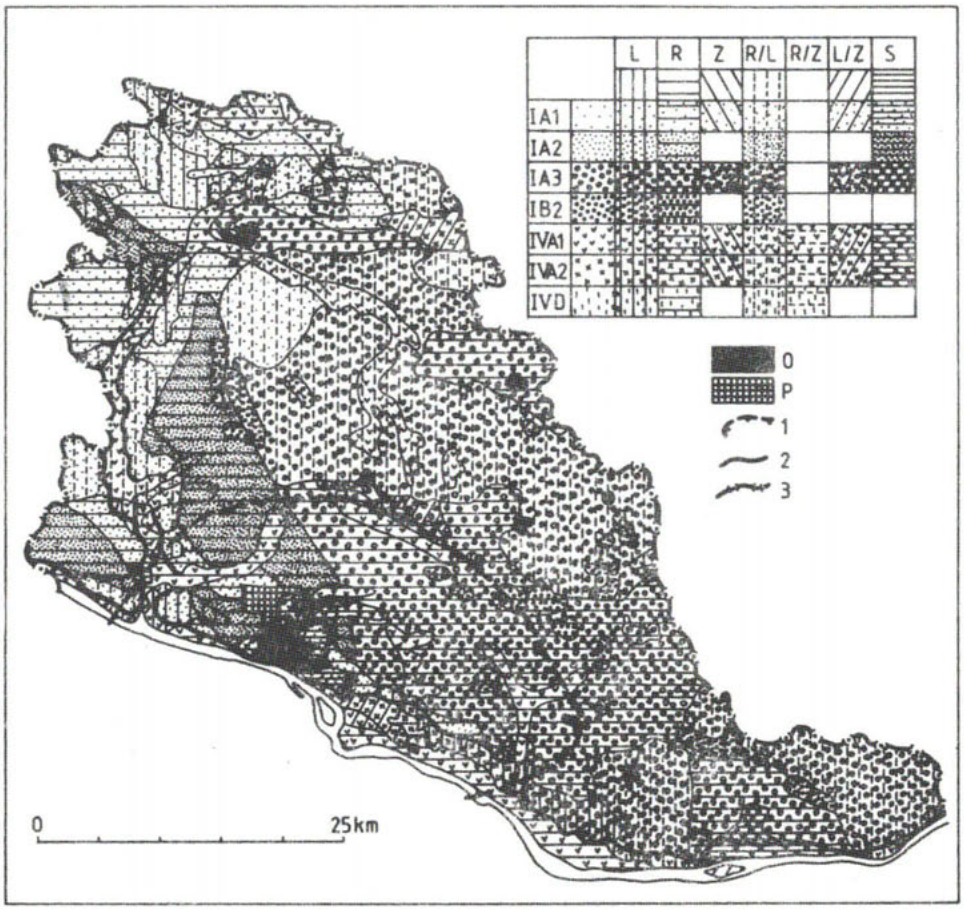

Fig. 1. A fragment of a map of landscape use in the Płock voivodship, scale 1:500,000 Due to the white and black form of presentation, the contents have been reduced (symbols of land use are described in the text). Types of natural landscape: I class — lowland; A sort — plain and hilly; kinds: A1 fluvioglacial, A2 glacial, A3 periglacial; B sort — hilly; kind B2 glacial and fluvioglacial; IV class — valleys and lowlands; A sort — inundated valley bottoms; kinds: A1 plains inundated in lowland and highland areas; A2 terrace plains in lowlands and highlands; D sort — marshy plains. .

1. approximate range of the environmental degrading effect of towns and industrial complexes
2. clear-cut undercuttings and edges
3. voivodship boundary

The analysis of the map permits to state that there is a high convergence between forest use and the poorest habitats and between grasslands and the range of river valleys.

Agricultural use in a majority of cases is connected with fertile or medium fertile soils. Attention is attracted by a clear concentration of mixed land use types (particularly the agricultural-forest type) in the northern part of the voivodship, that is within young glacial areas. Orchards and

areas of vegetable cultivation are distinctly concentrated near the largest towns. There is an unfavourable conflict between the Płock urban-industrial centre and vast forest areas, requiring protection and suitable for recreation.

The dependence of use on natural conditions in Płock voivodship was also presented graphically. The approach used by H. Richter (1981) was applied here for this purpose. The diagram (Fig. 2) shows the frequency of the particular types of land use within the limits of the particular landscape kinds. Also the average share of land use types within landscape sorts is presented.

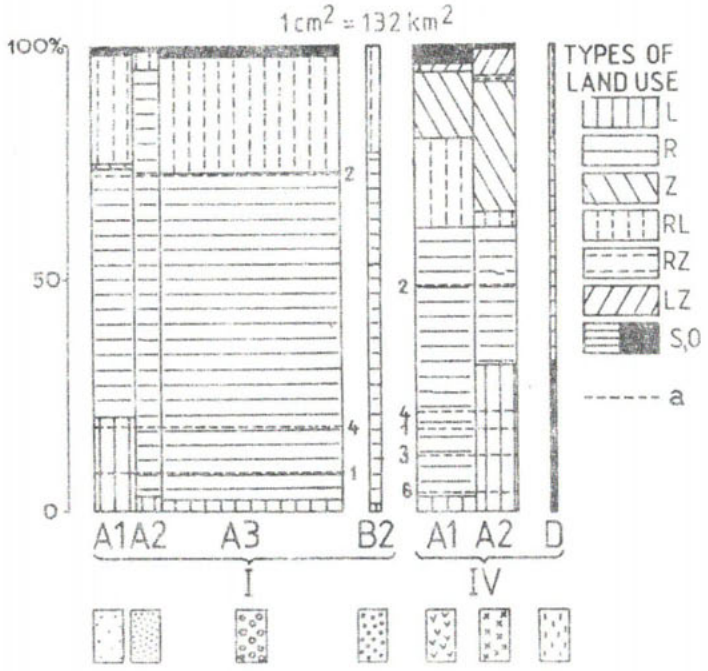

Fig. 2. Land use against a background of landscape types in the Płock voivodship
a — average share of the particular types of land use within sorts of landscape

Preparation of a landscape use map on the scale of 1:100,000 demands a somewhat different approach, particularly a large share of field studies. The attempt that was made concerns the northern part of the Płock voivodship. It covers an area of about 2400 km². The elaboration was based on itinerary field studies and cartographic materials on the scales 1:50,000, 1:100,000 and 1:200,000 (topographic maps and maps of lithology). Works on the map of landscape use were going on in two parallel directions; the starting point for a map of geocomplexes of the terrain type rank was a studio initial map of the geocomplexes on the scale of 1:100,000; this was followed by field mapping with application of a map

on the scale of 1:50,000. The mapping was aimed at verifying the borders of relief types and the lithological borders. In effect, a map of terrain types on the scale of 1:100,000 was produced. At the same time, an analysis was made of land use types occurring in the studied area in order to prepare a legend to the map of land use. Afterwards, the types of land use were mapped in the terrain, also with application of a base map on the scale of 1:100,000. Superimposition onto one map of borders of terrain types and contours of kinds of land use, after supplemented with additional information (described below) produced a map of landscape use on the scale of 1:100,000.

Field studies proved that many "areas" are not used in a homogenoeus way. There also exist geocomplexes or their fragments which are used clearly contrary to their natural predispositions. This is primarily connected with the structure of ownership of the mapped area. A majority of arable land is held in private hands, therefore most frequently there are small and medium-size farms of 5—10 hectares.

Under these circumstances, an assumption was made that land use is a decisive factor for distinguishing units of a lower order within the particular "terrain". The units were called "terrain variants".

Terrain variants were established by the marking of the main forms of use (that is a mostly anthropogenic complex) within "terrains" (that is strictly natural geocomplexes). Thus, they are typological heterogeneous units with uneven degree of internal differentiation. The units do not fit the accepted taxonomic systems of landscape units.

Borders of the "terrains" were determined mainly on the basis of classification of relief and surface lithology assuming that the other features of the natural environment are subject to certain arrangements of the components.

The following types of relief were separated:

— valleys and depressions, divided into:
  1) bottom plains of valleys and depressions,
  2) plains of higher levels,
  3) hilly areas;
— uplands with three types of relief:
  4) flat,
  5) rolling,
  6) hilly,
— slopes:
  7) steep slopes and escarps.

Lithology was divided with consideration for differentiation of surface material and its origin; the following types were distinguished:

1) peats,
2) silt, sand, gravel and alluvial materials,
3) fluvial and glacio-fluvial sands and gravel,

4) eolian sands,
5) glacio-fluvial sands and gravel,
6) glacilacustrine clay, silt and sand,
7) glacial sand, gravel and stones,
8) glacial clay (including also eluvial clay).

By combining both classifications, a network of the particular units — terrains was received which then were grouped in 23 types of terrains (marked with hachures on the map).

The distinguished types of terrains are units having the same features of origin and having relatively homogeneous features of natural environment. It was found out that to certain arrangements of main components (relief and lithology) are subjected waters, soils and natural vegetation. Descriptions of the particular types of areas were supplemented with short characteristics of their corresponding potential vegetation.

Then, after introducing the differences in land use, 58 variants of terrain types were obtained. Land use classification is similar to the division presented previously, while discussing the map on the scale of 1:500,000. Also here mixed types were introducted: agricultural-forest use (R/L), arable land-meadows (R/Ł) and forest-meadows (L/Ł).

The following rules were observed when distinguishing mixed forms of land use:

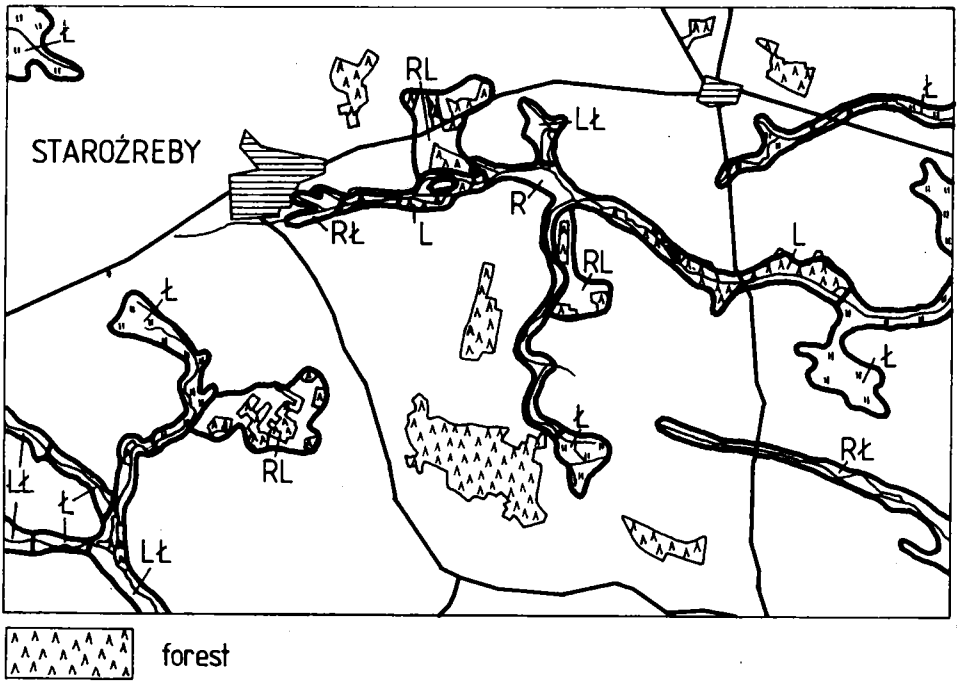

Fig. 3. An example illustrating determination of mixed forms of land use for a map of landscape use scaled 1:100.000

— the area of a given land use contour included into mixed forms must be below 0.5 km^2,
— the distance between the particular areas within mixed forms must not exceed 2 km.

The procedure is illustrated in Figure 3 which, for instance, shows that forests exceeding 0.5 km^2 were marked on the map in accordance with their outline in reality whereas dispersed forest fragments below 0,5 km^2, occurring among arable land, were classified as mixed agricultural-forest areas (R/L). The same procedure was followed for determination of other mixed types of land use.

The map of landscape use in the northern part of the Płock voivodship was supplemented, as mentioned above, with information on protection of natural environment and its anthropogenic transformations.

Thus, additionally were marked borders of nature reserves, borders of the existing landscape park, as well as the approved borders of protected landscape. The existing nature monuments were marked additionally. For this purpose a collective work was used, entitled "A Concept of Landscape Protection in the Płock voivodship" (1983). The existing borders were slightly corrected so that they corresponded to natural borders (that is borders of geocomplexes). Making use of a plan of spatial development of the Płock voivodship, as well as the authors' observations, also the areas predisposed to tourism and recreation were marked on the map.

Referring to the borders of geocomplexes, also the volume of annual pollution was marked for: vanadium, nickel, chromium, cadmium, lead, zinc, manganese and copper. For this purpose, a study was used entitled "The Study of the Impact of the Mazovian Refinery and Petrochemical Plant on the surrounding area" (1987) by A. Richling, W. Nowicki and W. Lewandowski. In accordance with the study, the supply of elements was presented in four ranges:

over 200 kg/km^2/year
121—200 kg/km^2/year
61—120 kg/km^2/year
below 60 kg/km^2/year

The borders of the last range are presented as blurred due to lack of such studies referring to the area of the entire voivodship. The method presented seems to be correct and the results more reliable than in the case of presentation of pollution supply in the form of a mechanically determined zone of influence.

The picture presented on the map takes into consideration a differentiated landscape pattern of the area in addition to meteorological factors.

An analysis of the map (Fig. 4 presents a fragment of the map for the neighbourhood of Płock, black and white version) produced the conclusions presented on page 22.

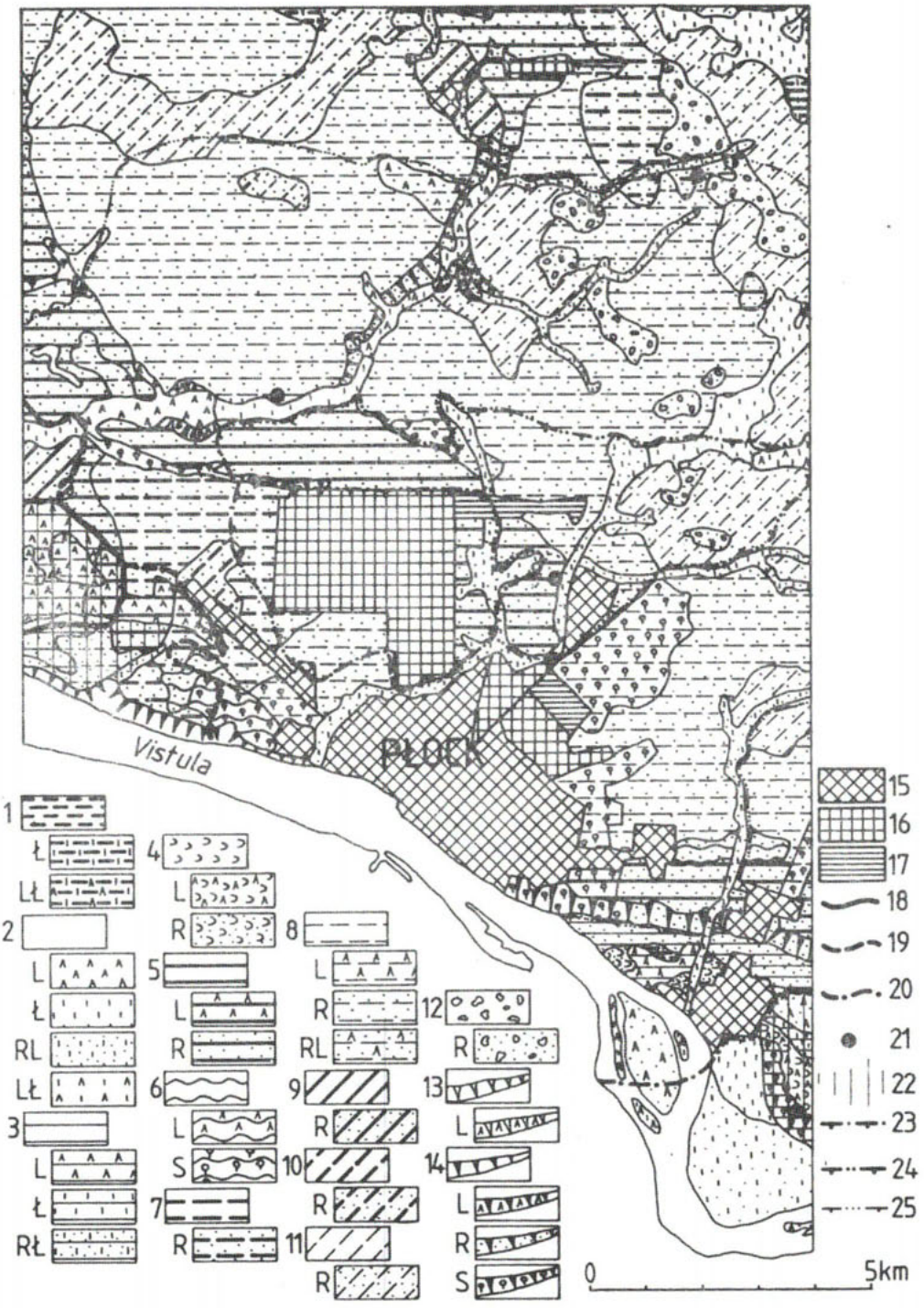
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Fig. 4

Fig. 4. A fragment of a landscape use map 1:100,000 — neighbourhood of Płock

Due to a limited size of the article, description in the legend was shortened as much as possible. To illustrate this the full description is preserved for "1".

1. Peat-bogged plains in the bottoms of valleys and depressions, characterized by shallow and very shallow soil waters, peat and swampy soils. To a great extent reclaimed land; Potential vegetation — alder swamp group (Carici-Alnetum).
   1. Ł Damp (Molinion) or sedge (Mangno caricion) meadows, pastures;
   2. LŁ mixed cultivation; forests and grassland (a mosaic type of land use including small areas of alder swamp forests as well as damp and sedge meadows and osiery (Salicetum pentandro cinereae) and other permanent grassland.
2. Plains in the bottoms of valleys and depressions, built of typical alluvial sediments (sands, gravel, silts and river clays).
   2. L marshy ash-alder forests and poplar-willow marshes;
   2. Ł damp meadows and fresh meadows;
   2. RŁ mixed use, mosaic type of land use — mainly root crops with a substantial share of grassland; damp meadows and fresh meadows;
   2. LŁ mixed use; mosaic type of land use including small areas of marshy ash-alder and poplar-willow forests as well as damp meadows and fresh meadows;
3. Flat higher levels of terraces built from alluvial formations.
   3. L marshy elm-ash forests with poplar added;
   3. R agricultural use; root crops dominating;
   3. RŁ mixed land use, mosaic type use — mainly root crops with a substantial share of permanent grassland, mainly damp meadows sown with grasses characteristic of fresh meadows;
4. Hilly type of relief (dunes and groups of dunes).
   4. L pine forests, artificially planted, referring to subcontinental fresh forest
   4. R grain crops;
5. Flat upland built of fluvio-glacial sands and gravel.
   5. L pine forests planted with an admixture of birch, made similar to subcontinental fresh forest;
   5. R agricultural use, grain and root crops;
6. Flat upland built of clays.
   6. R agricultural use, grain and root crops;
   6. S orchards, in the undergrowth layer groups of meadows similar to fresh meadows;
7. Flat upland built from glacial sands, gravel and boulders.
   7. R agricultural use, mainly grain crops;
8. Flat upland built of boulder clays.
   8. L pine forests made similar to mixed forests;
   8. R agricultural use, mainly grain crops;
   8. RL mixed land use, mosaic type of use, grain and root crops as well as pine forests, frequently with bushes, mainly with black-thorn;
9. Rolling upland built of fluvio-glacial sands and gravel.
   9. R agricultural use, mainly grain crops;
10. Rolling upland built of glacial sands, gravels and boulders.
    10. R agricultural use, mainly grain crops.
11. Rolling upland built of boulder clays.
    11. R agricultural use, grain and root crops;
12. Hummocky upland built of glacial sands, gravel and boulders.
    12. R agricultural use, mainly grain crops.
13. Steep slopes and escarps built of fluvio-glacial sands and gravel.
    13. bright forest or shrubbery with predominance of black-thorn and artificially planted pine forests;

14. Slopes and escarps built of boulder clays.
    14. L southern slopes are in fragments covered with bright forest or artificially introduced pines;
    14. R agricultural land use, root and grain crops;
    14. S orchards — in the undergrowth vegetation referring to stenothermal grasses or sand grasses;
    15. O settlements and urbanized areas (towns, dense settlements and larger villages, including also small industrial plants, smaller than the map scale, small traffic junctions, recreation-sports areas, parks and cemeteries),
    16. P industrial areas (large industrial plants, fuel reservoirs, waste-heaps and reclaimed areas);
    17. K transportation areas (larger transportation junctions and airports);
18. Borders of the Brudzeń Landscape Park.
19. Borders of the film of the Landscape Park.
20. Areas of the protected landscape.
21. Nature monuments.
22. Areas designed for tourism and recreation.
23. Annual supply of pollution.

1. There are clear connections between types of terrains and types of land use
    — forest areas predominate in the poorest habitats (flat uplands and slopes built of fluvio-glacial sands and gravels),
    — agricultural areas occur practically in almost all types of areas (which is not always connected with the natural potential of the natural environment),
    — grasslands predominate in flat bottoms of valleys and depressions,
    — orchards predominate in flat uplands built of glacial clays,
    — mixed agricultural-forest areas (R/L) occur mainly in flat uplands built of sands and fluvio-glacial gravels,
    — mixed areas arable land — meadows (R/Ł) and mixed areas forest--meadows (L/Ł) predominate in flat bottoms of valleys and depressions.
2. Orchards and fruit plantations are concentrated in the neighbourhood of bigger towns. In the case of Płock they occur in the zone of the lagerst pollution emitted by the Płock Urban-Industrial Complex, thus creating a clashing area.
3. Protected areas occur partly also within the range of the most intensive pollution, thus creating typical clashing areas.
4. Areas with tourist and recreation values are fully located within the areas of protected landscape which does not alter the fact that some of them are directly exposed to substantial pollution.
5. The existing borders of protected areas usually do not correspond to the natural borders.

Apart from the above-mentioned approach, attempts were made to draft a map of landscape use on a more accurate scale. For some time it has been an effect of complex studies organized every year within a system of training of geography students at the University of Warsaw. The studies are conducted by students and supervised by experienced members of the faculty, representing various fields of physical geography. Initially they were organized in a loess landscape near Sandomierz and recently they have been organized in a periglacial landscape in the Ciechanów voivodship. The works produced (with methodology changing) a map of small geocomplexes mapped in the fields on the scale of 1:10,000 or 1:25,000. Geocomplexes or more frequently types of geocomplexes are distinguished with an assumption of a primary role of relief and lithology as well as water depth in the soil connected with them. The structure of the units is studied on lines of selected landscape cross-sections which permits to follow also a vertical differentiation of the geocomplexes. The next stage is an evaluation of natural potential of subsequent contours on the unit map. The students make use of a special table-matrix which shows correct kinds of land use according to the bed rock, soil types and sub-types, slope value and water conditions. A list of defined types of cultivated plants depends to a large extent on the slopes. Along with growing slope value and a threat of erosion, field crops give way to orchards and vegetable gardens. The table also includes the most steep slopes which should be afforested. In such a case, according to other factors, a specific type of forest community is proposed. A detailed list of marks is contained in the legend to the presented fragment of the map of recommended long-term land use (Fig. 5).

A comparison of the proposed way to organize the area with the existing one is a summary of the whole procedure. The procedure constitutes a basis for development of a separate map of evaluation of landscape use in which all contours of geocomplexes are divided into those which are exploited in an optimal and correct way, according to natural predispositions. A separate group consists of geocomplexes which are used incorrectly from the viewpoint of natural properties. Figure 6 is an example of such a map. Both maps are supplemented with a text commentary which discusses treatments permitting to optimize the way of land use.

The presented maps of landscape use should be useful in planning necessary measures aiming at improvement of the way of space economy. They permit the evaluation of the exisiting way of utilization of resources of natural environment. introduction new forms of land use and optimization of the way of use. They should be a basis for spatial planning and measures aimed at protecting the environment. One should stress the role of such maps in teaching geography, as well as in general ecological education of the society.

In planning practice, special attention should be focused on areas with

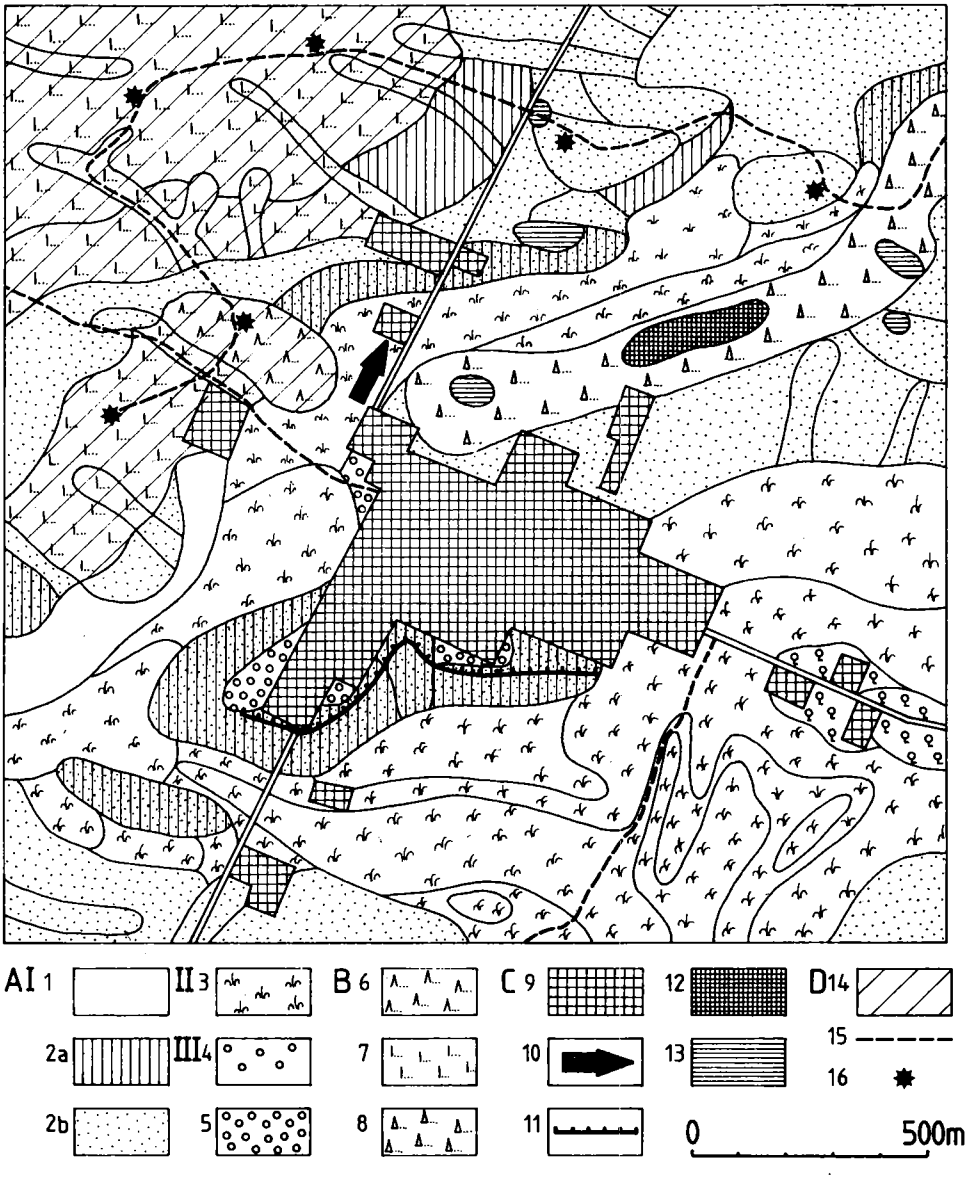

Fig. 5

Fig. 5. A fragment of a map of recommended long-term land use scaled 1:100,000 — neighbourhood of Żuromin

Geocomplexes with undefined taxonomic rank were determined on the basis of: classification of relief forms, lithology and depth to ground water. The description of units is presented in the form of a code in the map's background, e.g.:

IV G 2/1 means: low large-radius hillock (IV), with depth to water below 6 m (G) built of sand-gravel formations (2/1).

Recommended use:

A. Agricultural

I. Arable land

1. areas suitable for intensive use as arable land (agricultural usefulness complex marked)
2. areas suitable to be used as arable land with application of the following recommendations and restrictions:
   2a. proper cultivation (plowing along contour lines, limited use of heavy machinery)
   2b. intensive fertilization

II. Greenlands

3. areas suitable for intensive use as greenlands (pastures usefulness complex marked)

III. Fruit-growing and gardening

4. areas suitable for orchards (type of orchard marked)
5. areas suitable for gardening (type of crop marked)

B. Forestry (natural vegetation)

6. forests conforming to type of habitat
7. forests where stand of trees has to be restructured
8. areas to be afforested (with information on the type dominating in the stand of trees)

C. Settlements and industry

9. areas of settlements
10. preferred direction of settlements expansion
11. barriers to settlements development
12. industrial areas
13. areas to be recultivated

D. Recreation

14. areas with recreational values
15. roads with sightseeing values (tourist attractions)
16. scenic places

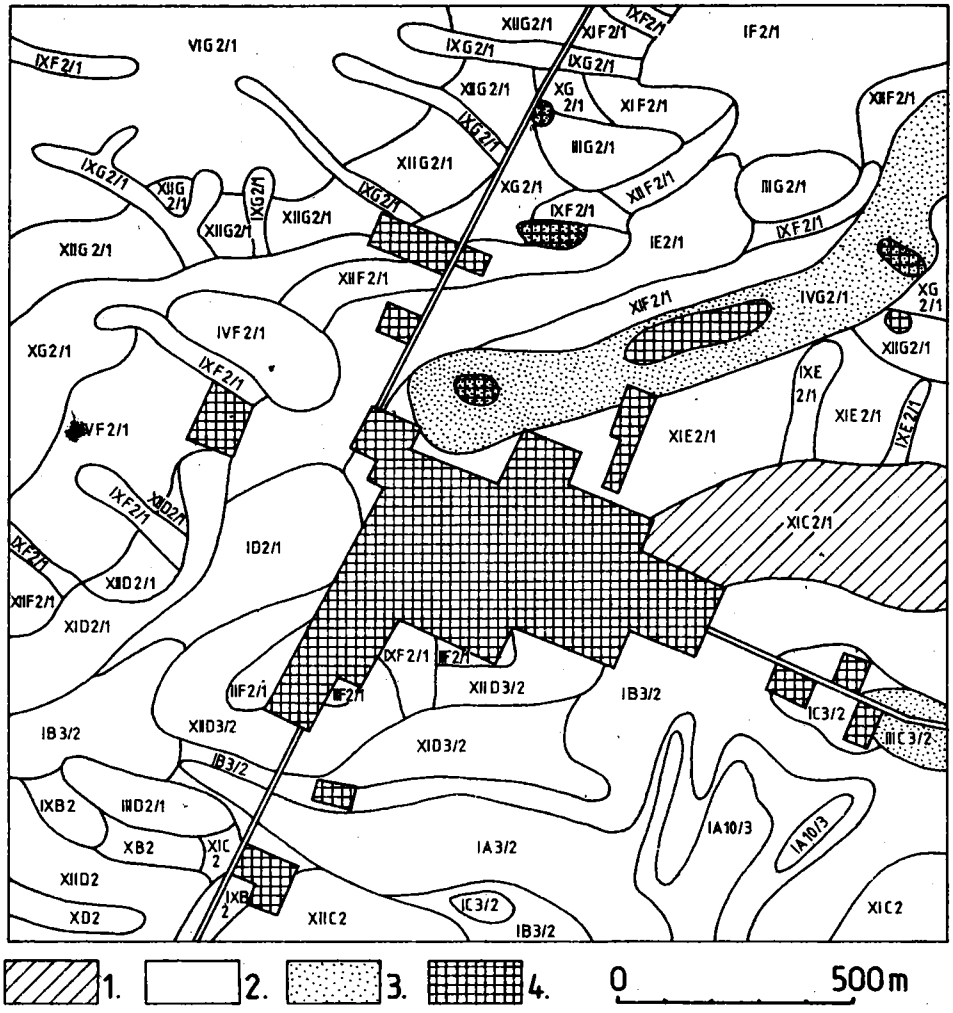

Fig. 6. A fragment of a map evaluating land use scaled 100,000 — neighbourhood of Żuromin

1. optimum
2. correct
3. incorrect
4. anthropogenic terrains

mixed use due to a higher intensity and variability of natural processes occurring within them and also due to the fact that within such areas there are possibilities to change the use. Uniform forest complexes and large agricultural areas should not change their use although their borders of composition in forests may be corrected. Also much care should be devoted to those areas within which there are conflicts between the way of land use and natural predispositions.

Usefulness of landscape use maps is determined by their accuracy. A map on the scale of 1:500,000 is designed for the needs of national and regional planning, a map on the scale of 1:100,000 should be used by voivodship authorities and in some cases by communal authorities, while a map on detailed scales may be useful with reference to particularly valuable areas or in studies on model areas. The results of these studies might later be used for larger areas.

REFERENCES

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