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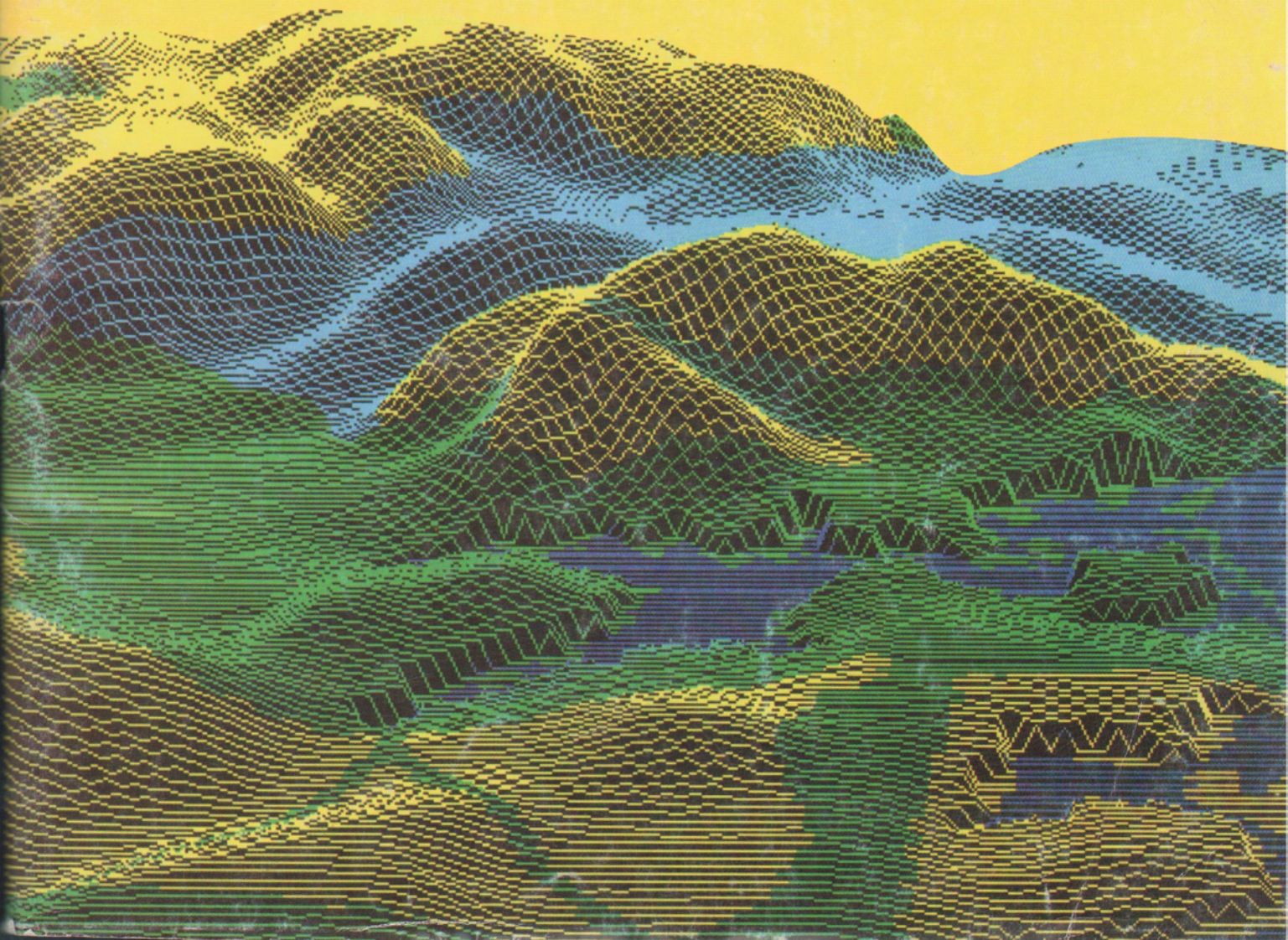

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LAND USE MAP

Miroslav Koželuh

Abstract

A land use mapping method based on the interpretation of satellite imagery is described in the paper. From various processes applied to obtain the information on parcelation and thematic contents of land use map, visual interpretation of multispectral false colour composite (FCC) of LANDSAT TM was used. Practical applicability of the method was verified by construction of a land use map at a scale of 1 : 50 000 from southern Moravia.

Shrnutí

Formy využití ploch

Informace o prostorovém rozmístění jednotlivých forem využití půdy je užitečná pro řadu oborů lidské činnosti. Její fixace v mapě má nevýhodu v poměrně rychlé ztrátě aktuálnosti. Při obnově, příp. tvorbě nových map tohoto druhu je proto velmi efektivní využití metod dálkového průzkumu Země.

Materiály dálkového průzkumu Země lze zpracovávat dvěma cestami v závislosti na druhu dat. V případě použití obrazových záznamů na magnetickém médiu je optimální vyhodnocovat informace dálkového průzkumu Země v digitální formě metodami počítačové interpretace. Druhý způsob spočívá ve využití obrazové informace ve formě fotografického snímku a interpretační postupy mají vizuálně-analogový charakter.

V článku je prezentována jednoduchá a levná metoda tvorby map využití půdy, vycházející z druhého způsobu, založená na vizuální interpretaci družicových snímků. Při konstrukci map tohoto druhu je základním úkolem přiřadit do zákresu hranic jednotlivých forem využití půdy (síť parcel) vlastní tématický obsah - t.j. aktuální způsob využití dané plochy. Informace o parcelaci i tématické náplni parcel je v popisované metodě získávána interpretací barevných syntéz (FCC), zhotovených z vizualizovaných multispektrálních obrazových záznamů LANDSAT Thematic Mapper.

Jako hlavního interpretačního znaku se využívá tónu snímku v jednotlivých částech elektromagnetického spektra, který určuje výslednou barvu studovaného jevu na barevné syntéze. V případě standartní syntézy je potom možné identifikovat objekty na základě jejich barvy. Standartizace barevné syntézy zahrnuje volbu spektrálních pásem, z nichž se syntéza sestavuje a výběr barev, přiřazených zvoleným spektrálním pásmům. Pro zhotovení mapy využití ploch byla na základě experimentování vybrána kombinace 3., 4. a 5. kanálu LANDSAT Thematic Mapper.

Praktická použitelnost metody byla ověřena na konstrukci mapy využití půdy v měřítku 1 : 50 000 z území severně od Brna. Byly rozlišeny tyto základní formy využití půdy: sídla a urbanizované plochy, zemědělské plochy, lesní plochy, vodní plochy, devastované a neplodné plochy. Tyto třídy byly dále podrobněji členěny na les listnatý, smíšený, jehličnatý, zemědělské plochy s vegetací a bez vegetace, atd. Mapa byla sestavena výhradně z dat dálkového průzkumu Země, bez použití nedistančních informací.

Key words: land use mapping, remote sensing, false colour composite

1. Introduction

The information about land use and spatial distribution of individual components of land cover is useful for many branches of human activities. Its fixation in the map work is disadvantageous due to a comparatively rapid loss of relevance. In Czech conditions, up-dating the content of such maps by classic methods does not guarantee sufficient operativeness irrespective of considerable financial demands.

In this situation, it is possible to use methods of remote sensing for compilation or up-dating of the map content of this kind. Application of the remote sensing methods has a long-term tradition in this field, and it is also possible to say that the expertise has exhibited the greatest possible spread as aerial and satellite surveys, thus representing the most complete and most up-to-date source of information for these purposes thanks to time and spatial homogeneity. High standard

has been achieved in evaluating the present situation of land use from image satellite recordings, obtained by satellites for research into natural resources (LANDSAT, SPOT) inclusive automated processing methods using computer techniques. It is mentioned in literature that with the help of photographs it is possible to determine the land use five times quicker than the classic methods (field mapping).

2. *Methodology*

Two ways can be adopted in evaluating the land use and generally in any specialized interpretation of remote sensing materials as related to the form of image information. In the case of using the CCT (computer compatible tape) recordings, it is optimum to process the remote sensing information in a digital form by methods of computer interpretation. The other way consists in using image-information in the form of photographic picture and methods of interpretation are of visual-analogous character. Choice of variant depends mainly on equipment with processing technique, less then on the form of remote sensing material source.

In the process of mapping the forms of land use, the main task is to include the proper thematic content, ie. the way of given land use, in the network of plots or other chosen division of the territory under study. At resolving this task by means of remote sensing which includes both satellite and aerial photographs, it is useful to apply a method based on interpretation of false colour composites, formed from multispectral images, and their evaluation from the viewpoint of spatial distribution of individual land use forms. By its complex conception of the studied reality with a possibility of observing spatial links and relations, this method is close to geographic approach to landscape sphere and moreover, represents consistent utilization of merits of a wide spectral engagement of multispectral information.

The main interpretation symbol used is tone of image in individual sections of electromagnetic spectrum, which determined the resulting colour of studied phenomenon on the false colour composite. The composites are created by combining individual zonal images and colours allocated to them optically or electronically by instruments called multispectral synthetisers or projectors. The resulting colour image is evaluated visually. Objects can be identified on the basis of their colour provided that we are familiar with meanings of these colours, ie. if we have an interpretation key for the given type of composite.

Should such an interpretation key, based on colours, have a wider applicability, it is necessary to work out a standard procedure of creating a colour composite, which would ensure reproducibility of results. Respecting this principle in the case of a image from unknown area will then enable correct interpretation of the image on the basis of knowledge of colour meanings, and in the case of a time sequence of composites from the same territory to deduce changes and processes which take place in the landscape on the basis of changed colours.

Standardization of the process of creating a colour composite should include selection of spectral zones of which the composite is made, including the choice of negative or positive version and that of colours allocated to the chosen spectral zones.

The choice of spectral zones for a composite aims at achieving a maximum number of colour scale tones on the colour composite, which makes it possible to differentiate the greatest number of phenomena possible. With attention being directed to just a certain phenomenon or an object, it is important for the observed phenomenon or the colour composite to be distinguished from its surroundings as much as possible. Profound knowledge of spectral characteristics of the observed phenomena, especially of the values of reflection in individual spectral zones, is very useful. As to the choice of colours for individual spectral zones, the decisive criterion can again be seen in the demand of maximum colour contrast and perhaps also aesthetic sense of the colour composite processor.

At observing the above mentioned preconditions, it can be stated that colours representing the corresponding elements on the colour composite are typical of the given element, which then can be identified on their basis. This fact is made use of at compiling intepretation keys with whose help the given composite type can be interpreted. The situation is somewhat complicated by a great number of colour tones that can be found on the composites. With regard to the fact that the number of items in the interpretation key is limited, it is necessary in the process of interpretation to associate the tones of colours into groups which correspond to individual items of the key.

Practical solution of compiling the land use map issue made use of the false colour composite made from image recording of LANDSAT 5,

scene no. 190/26 of the 10 May, 1987. The false colour composite was compiled by combining the channels TM3, TM4 and TM5 in such a way that the result of visual interpretation of land use forms could be transferred directly into the scale and projection of the used bottom map. The methodology of preparing a geometrically correct false colour composite was described by the author in great detail (KOŽELUH 1993).

The Basic map of the CSFR in the scale of 1 : 50 000, sheet 24-32 BRNO was chosen as the bottom map.

In the first stage of compiling the map in the scale of 1 : 50 000 from the area situated NW of Brno, borders of individual forms of land use (system of plots) were brought out from the composite onto transparent foil not only in agricultural plots but also in forests. The clue at depicting the boundaries consisted in colour changes of individual objects and in all line elements observable on the composite including the system of rivers and contours of water areas. No other auxiliary information of non-distance origin was used at doing this, which means that the parcelation reflects actual condition of landscape area structure at the date of scanning. Comparison of the parcelation diagramme with the map reveals an number of inaccuracies, namely at illustrating the ground plan of forest areas and even more so in settlements as well as in the course of communications and bank lines of waters. On the other hand, a generally known fact has been confirmed about a relatively exact reflection of the system of rivers in our maps. Not all the errors can be ascribed to generalization process at compiling the map.

In addition to the mentioned information for correction and more accurate compilation of maps, delineation of plots provides a qualitatively new information which is missing in common maps. This particularly applies to the possibility of determining the course of forest generic structure borders within forest complexes, and distribution of agricultural land to areas with uniform management - strips of land.

After the delineation of plots had been made, which is a rather difficult and time consuming stage of land use map compilation by the described method, the following step consisted in filling the system of plots with thematic information about the use of areas, obtained through visual interpretation of colour composites. A number of mutually different forms of land use that can be interpreted from the composite depends-through the mediation of criterion-on distinguishing capacity of the composite and determines extent of the land use map legend.

The map legend includes following items:
- urban areas (with residential and industrial functions)
- agricultural land with vegetation incl. permanent grass cover
- agricultural land without vegetation (ploughed land)
- forest land with prevailing coniferous stands
- forest land with mixed stands
- forest land with prevailing deciduous stands
- forest land denudated by felling (clear cut areas)
- devastated areas (quarries)
- water areas

Categories of permanent grass cover, orchards, hop-fields and vineyards are usually marked off in classic land use maps as an integral part of lands used for agricultural purposes. These forms of land use cannot be identified from satellite data of the given scale, because in their spectral manifestation they merge with other objects (permanent grass covers with agricultural land covered with vegetation, orchards and vineyards as related to the date of vegetation survey either with bare land or even with deciduous forest). For this reason, classification of the agricultural land into two sub-categories (with and without vegetation) was used in the map legend.

Colours depicting the individual forms of land use follow out of WLUS (The World Land Use Survey) recommendations.

3. *Discussion of results*

The land use map is enclosed in appendix. It was compiled by methodology described in the previous chapter, exclusively on the basis of satellite image interpretation, with no other supporting information.

The mapped area is distinguished by variety of land use forms composition. At linking up to the relief, expected localization of the individual land use forms can be corroborated. Elevated parts of the territory are covered with forests which-by estimate-occupy half an area of the map sheet. In terms of forest tree species composition, the category of forest, further divides into three basic forms: coniferous, deciduous and mixed forests. Representation of these sub-categories is rather uniform, and pronounced

dominance of the coniferous forest, which is common in the regions west of the area under study and is represented by Norway spruce pure stands, cannot be seen here. Apparently, as to interpretation of these forest classes, a certain percentage of inaccuracy must be expected. Plausibility of the interpretation cannot be verified (except for a round made right in the field) since the information on species composition of the forest is not available in any map of these scales.

There are further areas demarcated within the forest land, which have been devastated by felling that used clear cutting methods. Here, attention is deserved by a large unstocked area between Ostrovačice and Žebětín. Shortly before the image was made, the area had been massively deforested to enable construction of a racing track for automobiles and motorcycles (Masaryk Racing Track). Localities of mineral mining industries such as big quarries near Čebín, Lažánky and Tišnov have also been shown as devastated areas.

Areas and settlements used for agricultural purposes are situated in lower and flatter parts of the relief. Beside the SE map quadrant which is practically filled with urban areas of BRNO, Blansko, Tišnov and Kuřim, the remaining part of the area under study exhibits housings of rural type. Success of intepretation of settlements depends on character of these residences. Urban-type settlements with a high proportion of inorganic surfaces such as roofs, buildings, communications, can be interpreted without any difficulties. On the other hand, rural settlements with a high proportion of vegetation do not provide sufficient contrast to their surroundings, which can make their identification impossible in practice. It is obvious from the map that it is mainly boundaries of settlements at places where they merge into open landscape, which are sometimes not delineated in full agreement with ground plan of the bottom.

Areas used for agricultural purposes, which cover the flat relief in depressions can well indicate for example the course of Boskovice ridge in the map. In the composite, agricultural land was manifested in the whole range of colour tones in dependence on the proportion of green and non-green components of active surface, ie. on the level of land cover with vegetation. The map legend included only the two extreme conditions: agricultural land with vegetation and without vegetation, transient cases being included in one or the other class according to the proportion of vegetation and bare land.

4. *Conclusion*

The land use maps provide valuable information about actual condition of landscape sphere. They find particular application in territorial decision-making activities of administrative bodies, being at the same time one of essential elements of the GIS databases. Their compilation and up-dating with the use of remotely sensed data appears to be effective from both financial and time viewpoints.

The method used for compilation of land use map on the sheet 24-32 BRNO (ie. visual interpretation of colour composites) has been proven suitable for workplaces with no available instrumentation for digital processing of image information. It is based on human factor and makes full use of experience from interpreting colour composites.

Value of the map is a product of its time (1988) and of the fact that no other non-image informations were used for its compilation. The "genuine" approach of remote sensing at creating maps of this kind has already been surpassed, and utilization of all available data (including terrain survey to verify interpretation of critical localities) facilitates to compile the land use maps by means of remote sensing image material, whose legend contains up to three times the amount of items when compared with this map.

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Reviewer

RNDr. Vítězslav Nováček, CSc.

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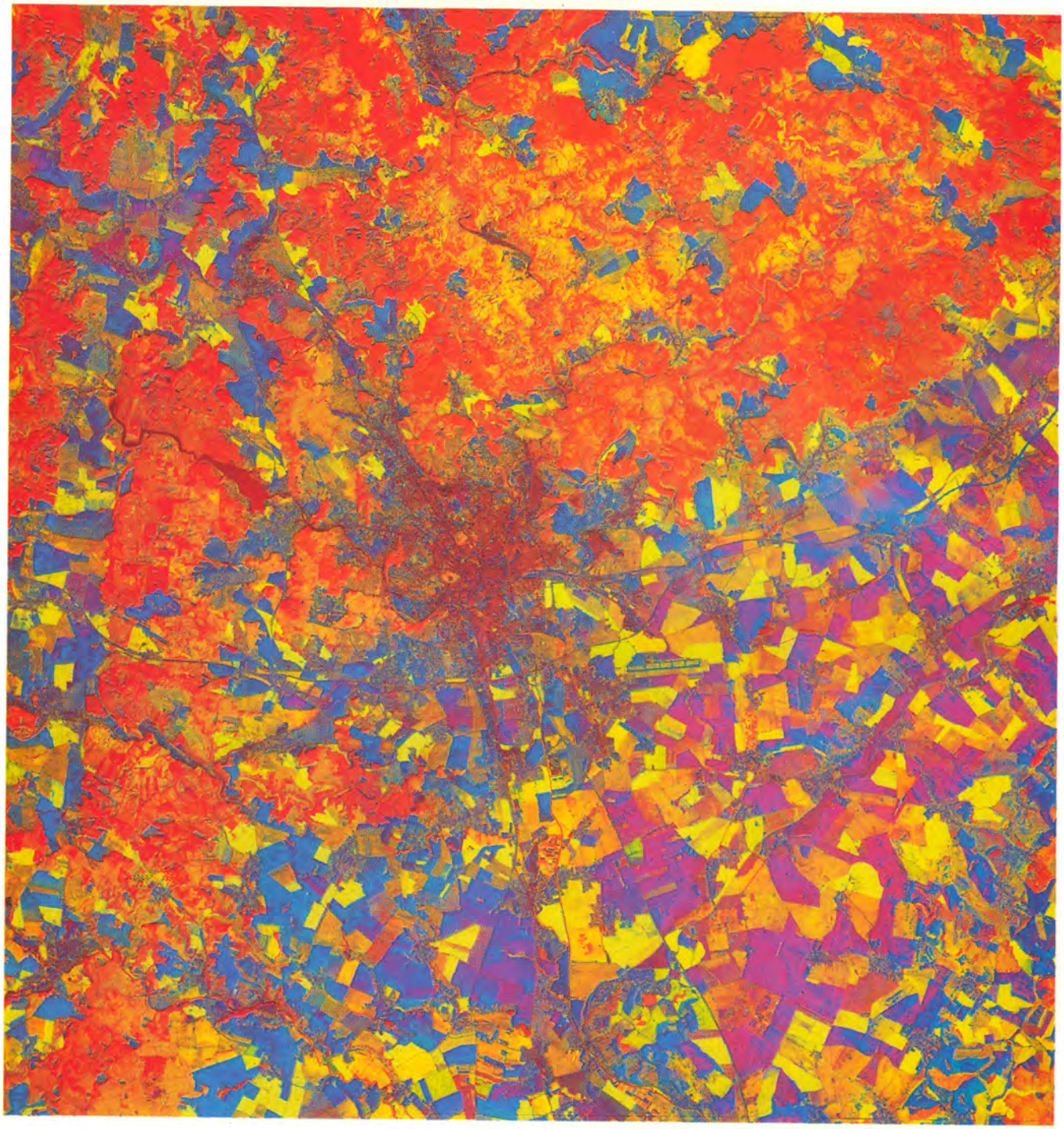
Explanations to the map - Appendix No. 3

(the numbers correspond to numbers in the legend of enclosed map)

1 – urban areas (with residential and industrial functions)
2 – agricultural land with vegetation incl. permanent grass cover
3 – agricultural land without vegetation (ploughed land)
4 – forest land with prevailing coniferous stands
5 – forest land with mixed stands
6 – forest land with prevailing deciduous stands
7 – forest land denudated by felling (clear cut areas)
8 – devastated areas (quarries)
9 – water areas
10 – water streams
11 – important roads
12 – boundaries of land use forms

Pavlov *Photo: O. Mikulík*



The example of colour composite used at compilation of the land use map, sheet 24-32 Brno (Information source: © ESA/Eurimage)

3

ZÁKLADNÍ MAPA ČSSR

ČESKÝ ÚŘAD GEODETICKÝ A KARTOGRAFICKÝ

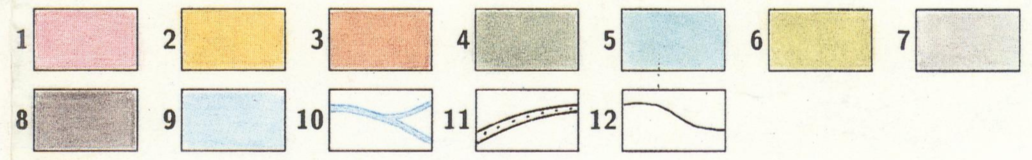
24-32 Brno

1:50 000

1 cm = 500 m

1000 m 500 0 1 2 3 4 km

Základní interval vrstevnic 10 m



FORMY VYUŽITÍ PLOCH:

1 - zastavěná území (s obytnou a průmyslovou funkcí); **2** - zemědělská půda s vegetací (včetně trvalých travních porostů); **3** - zemědělská půda bez vegetace (zoraná půda); **4** - lesní půda s převládajícím porostem jehličnatých dřevin; **5** - lesní půda se smíšeným lesem; **6** - lesní půda s převládajícím porostem listnatých dřevin; **7** - lesní půda obnažená těžbou dřeva (holoseče); **8** - devastované plochy (lomy a hliníky); **9** - vodní nádrže; **10** - vodní toky; **11** - významné komunikace; **12** - hranice forem využití ploch.

Mapa forem využití půdy byla zkonstruována výhradně s využitím obrazové informace z družice pro výzkum přírodních zdrojů "LANDSAT 5". Metodou vizuální interpretace barevné syntézy, sestavené ze 3., 4., a 5. spektrálního pásma skaneru "Thematic Mapper" bylo možné vyčlenit v legendě uvedené formy využití ploch. Mapa zachycuje stav ke dni 10. 5. 1987.

SOUBOR GEOGRAFICKÝCH MAP ŽIVOTNÍHO PROSTŘEDÍ

FORMY VYUŽITÍ PLOCH

List 24-32 Brno, měřítko 1:50 000. Zpracováno v rámci dílčího úkolu SPZV II-7-4-01 "Geografické hodnocení stavu a vývoje životního prostředí na území ČR", odpovědný řešitel dílčí části RNDr. Evžen Quitt, CSc. a dílčího úkolu SPZV II-7-4-06 "Metody dálkového průzkumu agrotechnického geosystému na území ČR", odpovědný řešitel dílčí části RNDr. Jaromír Kolejka, CSc.

Autor listu: **RNDr. Miroslav Koželuh, CSc.**

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