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Photomorphic Mapping for Land-Use Planning

Photomorphic mapping techniques were employed to delineate land types and, thus, to aid in land-use planning in Boulder County, Colorado.

The photomorphic mapping method as described by MacPhail (1971), is a means of acquiring information about land systems through the use of patterns on aerial photographs. The concept depends on the recognition that definite relationships exist between components on the ground comprising the land system. These are represented on the aerial photographs in the form of distinct patterns, which may differ greatly between areas, according to features such as vegetation, geology, soils, drainage, field and settlement patterns, etc. These landscape components, therefore, form the distinctive physiographic region, and also, the distinctive photographic image. It is thus possible to separate and map different land types for regional planning purposes since similar landscape conditions in general obviously warrant the application of similar planning policies.

Abstract: *A comparison of different land types based on their physical and environmental characteristics is seen as a useful, if not vital, element of land-use planning decisions. The use of the photomorphic mapping technique is described, in order to delineate and compare the different land types in Boulder County, Colorado, according to their constraints and values for agricultural and urban uses. Using high-altitude color infra-red aerial photography of Boulder County at a scale of 1:100,000, photomorphic areas were delineated according to similarities in pattern, tone, and texture on the photographs. The boundaries of the areas were checked and adjusted using information from thematic maps and sampling data. Constraints on specific land uses in the County could then be described on a regional basis, using the photomorphic areas as a framework.*

Because the interpretation of patterns rather than individual components can compensate for the loss of resolution on smaller scale imagery, the use of widely varying scales of imagery is possible. The method is therefore not only effective for rapid reconnaissance surveying of large areas where little mapped information is available, but also is useful in more densely populated regions, where already existing information in map form would be more useful for planning purposes when combined into a regional framework.

This paper attempts to show how the photomorphic mapping method can be used for land-use planning in a rapidly urbanising region where not only agricultural information but also information relevant to localised engineering constraints in different land types becomes important. Thus the photomorphic areas are used as a framework, or model to which more detailed, thematic information can be related, for use in more specific site planning. The regional framework is also essential for long term zoning in the context of the broader planning region.

Robertson (1968) states:

> It is obvious that first stage surveys do not provide many answers, but they should indicate where the answers should most profitably be sought. If they can be conducted rapidly, and at small cost, they are justifiable.

Photomorphic Mapping in Boulder County, Colorado

The aim of the study was to suggest the most suitable kinds of land use for each particular land type in Boulder County, first by using the photomorphic method to delineate the land types, and second, by indicating the major land-use constraints in each area.

Boulder County is used here as the study area (Figure 1) since detailed information is available in the form of thematic maps and reports by NASA, 1972[1,2] and because the need for input to planning studies was immediate.

Methods

Land types were delineated on the basis of pattern, tone and texture on the aerial photographs, and substantiated by field observations, interviews and census information, as well as by the available maps. Within the resulting regional framework the major land-use constraints, namely slopes of over 30 per cent, aquifer recharge areas, 100-year flood plains, fault zones, fire hazard areas,

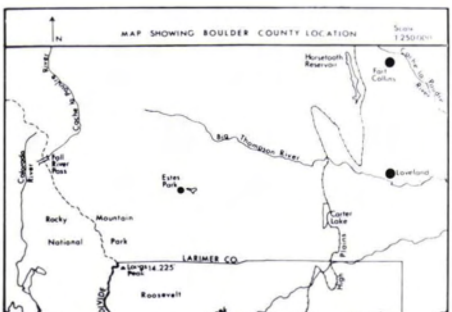

Fig. 1. Study area.

Fig. 2. Black and white infra-red aerial photograph of the City of Boulder. Photomorphic areas are delineated in black.

soil and bedrock engineering capability and the presence of high quality agricultural land could be indicated, and the most suitable kinds of land use suggested in each land type for the formulation of long term planning policies.

Photomorphic mapping was carried out using 1:100,000 scale 9 x 9 inch color infrared transparencies[1] from which black-and-white print reproductions were made (Figure 2) as a base for the delineation of photomorphic areas using both planimetric and stereoscopic viewing. Subsequently the boundaries were refined using larger scale thematic maps of bedrock geology[2], soil agricultural capability,[3] soil engineering capability,[4] wildfire hazard, slope,[5] and

[1] Aircraft imagery from NASA missions 205 and 211 taken in support of "An interdisciplinary evaluation of ERTS data for mountain environments using ADP techniques," ERTS Contract No. NAS5-21880, University of Purdue, L.A.R.S. and I.N.S.T.A.A.R., University of Colorado, Boulder, Colorado.

[2] N.A.S.A., 1972, Bedrock Geology Map and Report, Grant NGL-06-003-200, I.N.S.T.A.A.R., University of Colorado, Boulder, Colorado.

[3] U. S. Department of Agriculture, Bureau of Chemistry and Soils, 1935, 'Soil Survey of the Brighton Area, Colorado,' and 'Soil Survey of the Longmont Area, Colorado,' (Series 1930 Nos. 1 and 29), Government Printing Office, Washington, D.C.

[4] U. S. Department of Agriculture, 1973, 'Boulder Survey Area,' Donald C. Moreland (Compiled). (In press).

[5] U. S. Department of Agriculture, Forest Service, 1973, Wildfire Hazard Maps, Boulder County.

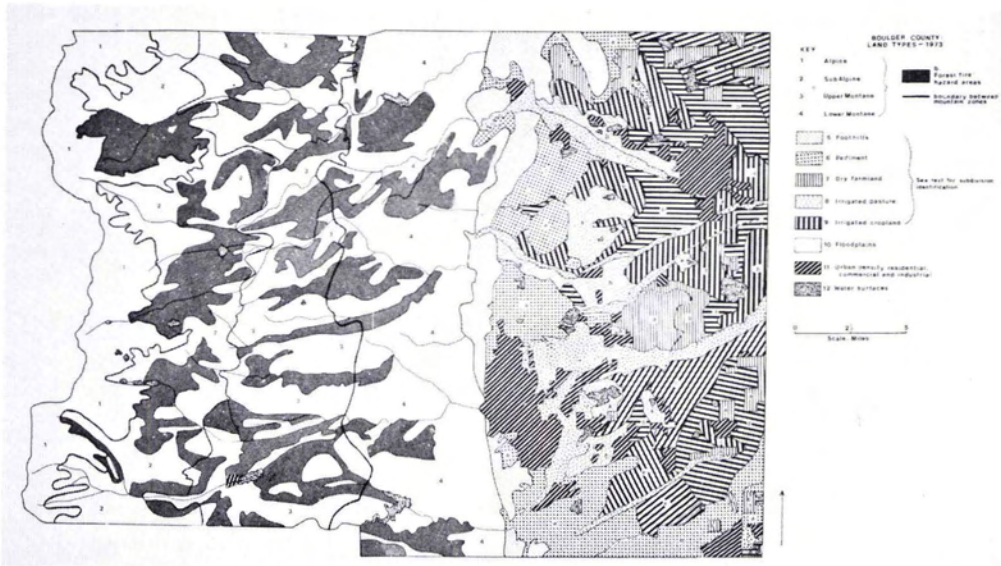

Fig. 3. Land types.

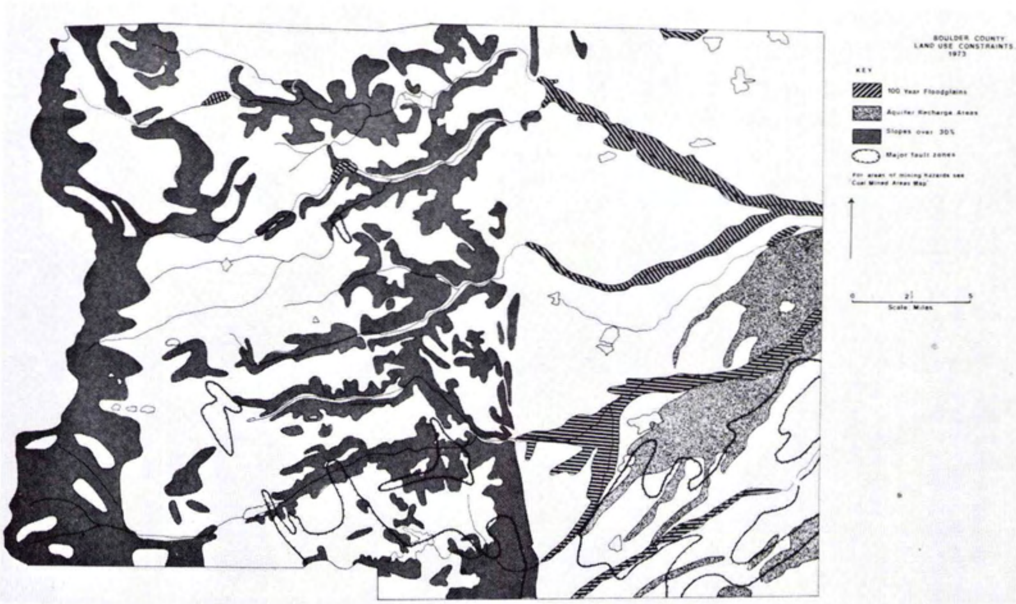

Fig. 4. Land-use constraints.

vegetation.[6] In each case, information from the thematic maps was related subjectively to the areas provided by photomorphic mapping.

More detailed information from field observations and interviews, tax assessment and land tenure records was obtained for smaller areas selected by stratified random sampling. Limitations of time did not permit larger than a 5 per cent sample in the present study, although a fuller sample would have provided detailed, reliable information applicable to extensive areas, defined according to similarity of pattern on the photographs.

[6] Derived from experienced aerial photographic interpretation.

LAND TYPES

Figure 3 shows the land types, or photomorphic areas, and Figure 4 shows the major land-use constraints which were related to the land types. A suggested ranking of the physical and environmental constraints on land use, both for agriculture and for urban development is given in Table 1. One of the sub-types is described here, in order to exemplify the application of the photomorphic method to actual land areas.

LAND TYPE 9 (IRRIGATED CROPLAND): SUB-TYPE 9C

Photomorphic appearance: Medium textured, medium to dark grey tones are subdivided by the light-toned quarter section boundaries. Fields are straight sided and either square or elongated with a 6-to-1 length-width ratio. Overall appearance is uniform except for the highly contrasting field boundaries.

Geographic description: This is almost flat land with a slope of between 1 and 3 per cent and corresponds to fertile Greeley and Weld fine sandy loams, and Fort Collins loams. Bedrock is almost exclusively Foxhills sandstone.

The main disadvantage for agricultural land uses is a shortage of water towards the end of a dry year. Consequently there is more emphasis on feedlot livestock rearing, with the main crops grown used mainly for fodder. Some of the land is in pasture, in rotation with fodder crops. Farm and field sizes are small, ranging from 60 to 160 acres and 20 to 25 acres, respectively.

Both sample sections showed signs of moving towards higher intensity use. Farms were almost exclusively owner-operated though land ownership was seen to be changing rapidly. Tax assessment information showed many recent land sales to distant buyers, real estate companies and known land developers. Three of the owner farmers interviewed had continual pressures to sell the land and were prepared to do so at a favourable price.

CONSTRAINTS ON LAND USE

On the whole, this land type is only marginally inferior for agriculture to types 9a and 9b, the highest quality irrigated cropland. Soils and bedrock both offer few constraints for engineering pur-

TABLE 1. RECOMMENDED DEGREE OF CONSTRAINTS FOR AGRICULTURAL AND URBAN LAND USE (MAXIMUM CONSTRAINT = 10).

	Land Type	Area Sq. Miles	Agriculture	Urban
1	Tundra	60	10	10
2	Sub Alpine	109	9	9
3	Upper Montane	122	6	6
4	Lower Montane	126	7	7
5	Foothills	29	6	8
6a	Pediment	30	5	2
6b	Pediment	13	6	6
6c	Pediment	9	4	2
7a	Dry Farmland	9	4	2
7b	Dry Farmland	6	3	6
7c	Dry Farmland	8	4–5	4
8a	Irrigated Pasture	18	4	4
8b	Irrigated Pasture	14	4	4
9a	Irrigated Cropland	15	0	5
9b	Irrigated Cropland	46	0	5
9c	Irrigated Cropland	13	1–2	6
9d	Irrigated Cropland	11	2–3	2
9e	Irrigated Cropland	24	3–4	3
10	Geomorphic Flood Plains	35	4–5	*10/5
11	Urban Density Residential Commercial and Industrial	44	10	10
12	Water Surfaces	9	10	10

* 100-year flood plain.

Note: The following factors must be considered additionally to the values assigned in the table: geologic faults, mining subsidence, wind hazard, aesthetic factors.

poses but because of the aquifer recharge capacity of the Foxhills sandstone bedrock, high density development would endanger groundwater quality, particularly if septic tanks were used.

Conclusions

In the light of the present study, a possible solution to both the problems of urban sprawl, and to the loss of agricultural land, would be to impose growth controls on the edges of the already built-up areas which correspond to good agricultural land, or to aquifer recharge areas, or 100-year flood plains (Land types 9a, 9b, 9c, 10, 11 12) and to cluster development in other locations with low engineering constraints (e.g., land types 6, 7a). The marginal additional investment necessary to overcome the engineering limitations imposed by soils and bedrock would seem negligible compared to the irreversible loss of agricultural land.

In the mountain region, all land is either steeply sloping, forested, or possessing low capacity for wells and septic tanks. Soil erosion, slope failure, fire hazard, groundwater pollution, and exhaustion of the groundwater supply are all possible results of increased development intensity, as well as the threat to the aesthetic and recreational qualities of the land. While site investigations could reveal favorable sites, extremely low density development of approximately one-house-per-three-acres would seem advisable, with prohibition of development in the alpine and sub-alpine land types.

Summary

The areas defined by photomorphic mapping in Boulder County represent actual physical and cultural conditions which correspond to specific land types. The main advantage of the method was found to be the ability to define and describe large areas of land rapidly and in detail, using aerial photographs and sampling investigations. Reference to thematic maps was useful in confirming and explaining initial observations and in almost every case the initial observations proved to be consistent with map, census, and field information.

Physical land characteristics in each land type were interpreted in terms of land-use constraints which were evaluated separately for agricultural and urban uses. These were thought to be the two major conflicting uses at the time of the study, though other possible land uses such as recreation could have been considered.

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