Landscape Maps as an Aid to Management of Scenic Mountain Areas[1]

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Abstract: Before any question about wise management decisions concerning the visual resource of our environment can be answered, it is necessary to conduct a detailed analysis to determine the integral visual inventory of landscape, as it impresses any involved person. With this method of landscape analysis researchers and planners can specify the potential of any region with an approach suitable for the problem. The knowledge about visual landscape elements is, in addition, a requirement to comprehend their influence on the motivation of any visitor or inhabitant.

INTRODUCTION

This paper discusses landscape analyses in the Swiss UNESCO MAB 6A Program [3/] (Impact of Human Activities on Mountain Ecosystems), and in the Indian Peaks Region of the Colorado Front Range. It covers the Swiss Diploma work of Roland Baumgartner and also provides an outline of research recently initiated in the southern Rocky Mountains which will later be continued as part of the Swiss 1ºMAB Program. The Indian Peaks section of the Colorado Front Range has been selected because it is the object of an intensive study by the Institute of Arctic and Alpine Research (INSTAAR). This study will result in production of an Environmental Atlas for a newly created Wilderness Area in the Indian Peaks and a contiguous UNESCO-MAB Biosphere Reserve (Niwot Ridge). The work is a team study supported by a research grant from the National Aeronautical and Space Administration (NASA) to J.D. Ives (Principal Investigator). It is part of a NASA program to study the applications of space technology to the solution of land-use problems.

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[3/] UNESCO Program "Man and the Biosphere(MAB)".

The two studies, Aletsch (Switzerland) and Indian Peaks (Colorado),will be expanded later as a combined Swiss - United States MAB 6 undertaking, a study of the impacts of human activities on mountain ecosystems.

SET OF PROBLEMS AND OBJECTIVES FOR THESE LANDSCAPE ANALYSES

Since the middle sixties the functions and processes in natural landscape systems have been increasingly studied by university institutes and by different agencies as a specific new branch of environmental science, called "Landscape Ecology." These approaches are consequently directed to solve capability problems (suitability of regions as settlement places, as recreation areas, etc.). Besides traffic, energy, mining, air pollution and so on, the potential of landscape experience for every involved person has been elaborated as one of the principal factors of natural applicability. One problem seems to be neglected quite often in this context. Many studies are restricted to only a few visual factors and elements, which appeared in the initial stages as if they would be dominant. They were used to solve the question about the theoretical capability of a region. But, these factors usually cannot characterize the landscape as an integral whole and critical examination of the applicability is therefore mostly too specific. For example, either vegetation or relief or scenic views have been taken into consideration only as single aspects. Researchers and planners have been mapping ecological data in a "single disciplinary manner." At the present time no one is analyzing and interpreting the overall

visual aspect of the environment.

As the sub-title of our National Landscape Conference says, we are attempting to summarize the available applied techniques for analysis and management of the visual resource. Before any management decisions, or any qualifications about the value of a visual environment can be made, it is necessary to conduct a detailed analysis to determine the integral inventory of the visual landscape aspects as they impress different groups of involved people.

The goals of our landscape studies include the following:

- First, that the Basic Maps, when compared, provide a check on the effectiveness of different mapping approaches to facilitate perception of various visual aspects of landscape. They also provide accurate information about mutual dependences of natural and man-made factors. This work has been accomplished in the Aletsch Region and is described in the section on Basic Maps (fig. 1 and 2).*
- Second, the combination of visual aspects into one map, showing "Combined Dominant Visual Landscape Types" is an experiment to determine landscape units (classes) as integral over all relevant elements for the perception of the visual landscape. These data have already been utilized as an invaluable component in completing the "Rocky Mountain National Park Comprehensive Boundary Study Report" to the U.S. Congress. This step is also an indispensable basic requirement to extract elements which are significantly influencing involved people in their motivation and thinking about a region. This work is being conducted in the Indian Peaks and is discussed in the section on Combination of Aspects.

BASIC MAPS: PERCEPTION OF A MOUNTAIN LANDSCAPE

(Study Area: Aletsch Region, Switzerland)

The initial landscape analysis produced three basic maps (slope, geomorphology, and land use) which present three aspects of the environment from three different points of view. The idea to produce these landscape maps comes from the three main approaches to, geography:

a) formal/descriptive studies, which characterize landscape forms and structures most objectively by measuring, counting, or simply characterizing certain features by a concrete description (e.g., a certain slope has a certain angle of inclination and is composed of a certain material with a certain grain size);
b) genetic/historical studies, which tell about the origin and historical development of the landforms. This approach corresponds most appropriately to the mathematical term of a "function." Landscape is therefore "a function." of different factors" (e.g., this slope is a glacial deposition site and is caused by glaciers' moraines);
c) functional studies, which, in contrast to the genetic/historical studies, "look forward They elaborate the uses of a certain element by telling us how it is used today, and what former uses are still obvious, as well as what uses it is developing toward. Landscape has in this case "the function that..." (e.g., this approach informs us that the above slope is a former grazing land, now abandoned, and its appearance results from this fact).

Objectives and Specific Results of Each of the Three Basic Maps

The slope map -- The slope angle is obviously one of the most efficient criteria to typify a natural mountain landscape and to interpret land use. It is also significant in characterizing relief , and both recent and former processes. Slope maps provide the best description of mountainous landforms: terraces, gentle ridges, large valley bottoms, and deposition areas are distinctly separated from steep slopes, V-shaped valleys, and rockfall areas.

The geomorphological map -- (see also figure 2*). Its aim is to give detailed information about the origin, structure, genesis and dynamics of the landscape's surface. This map is not comparable to a complete morphologic, morphogenetic or even morphodynamic study because of its orientation to visual features only (e.g., the structure and composition of surficial deposits are only relevant if they are influencing the surface expression of today's landscape).

Figures 1* and 2* show the landscape of Martisberg, Aletsch Region, Switzerland, on a photo taken from the opposite valley side and on a part of the "Geomorphological Map Aletsch." The photo to the left provides particular information about actual land use patterns; it gives an idea about the functions of the different areas: traffic and intensive agriculture in the valley bottom, settlements and quite intensive agriculture on the gentle, unwooded slopes, and alpine pastures around and above treeline. The forest covers steep slopes and jagged V-shaped valleys edging the cultivated land. Avalanche and erosion paths can be observed in the forest areas.

The Geomorphological Map (right photo), however, defines the origin of the different landscape types and their uses: moraine deposits are to be found in the cultivated areas,

*See color illustration on page 388.

and rough weathering and its deposits in the small valleys. Subsidence causes the terrace for alpine pastures and for possible tourist settle-ments.

The following type of legend has been used to determine "Morphological Landscape Types" in the Aletsch Region:

215 Subsidence area

Outcrop bending

216 Deep weathered bedrock

Disrupted rock

Bare bedrock, not disrupted

231 Detrital material

Boulders } vegetated/
Debris slope } no vegetation

237 Alluvial plain

241 Moraine material

242 As 241 but affected morphodynamically

Moraine hill

Exposure/Erratics

251 Actual morphodynamics

Landslide

Abrasion by snow

271 Avalanche path (in forest areas)

Debris cone

Gully erosion

Cattle paths

Wet area: depression

Wet area: source

A Forms caused by man

The most striking characteristic of this map is the good division of this mountain landscape. Many of the well-known types of landforms are defined scientifically. This kind of study awakens the comprehension of landscape development and its causing factors. It gives an idea about "Landscape Ecology."

The land use map -- The Swiss MAB Program applies basically the following essential functions for a mountain area: protection (from natural hazards, but also in the sense of protecting the natural ecosystem), revenue from natural resources (agriculture, forestry, energy, water supply, mining, etc.), and recreation (general attractiveness for inhabitants and visitors). The objectives of our land use map are to answer these questions: "How is this area developing (naturally or caused by man)?" or: "What is (or was) it used for; what production aspect does it provide?" The "functions" of the earth's surface are therefore: natural (natural vegetation or vegetationless); caused by man (cultivated land for forestry, settlements, etc.); or formerly influenced by man and now abandoned.

The land use map should be complementary to the slope and geomorphological map. It should, when compared with the first two maps, show which main uses were possible in past times under natural conditions and which ones are feasible today, as well as what processes might occur if the exploitation is changed. This kind of land use map does not describe the theoretical, or general potential of the landscape. It gives useful aspects about the land's capability by describing patterns which are exclusively appearing visually.

For the Aletsch area agricultural use was the most obvious feature for a "functional map" (see introduction to Basic Maps). But this system of mapping is open to all kinds of land types, natural or man-influenced, so it can be used easily in other regions.

THE COMBINATION OF DIFFERENT VISUAL LANDSCAPE ASPECTS INTO ONE MAP, SHOWING COMBINED DOMINANT VISUAL LANDSCAPE TYPES

(Study Area: Indian Peaks, Colorado)

First, this step describes completely the visual impression of the "natural landscape" on a visitor or inhabitant, although it does not address how the landscape is interpreted (landscape is, in contrast to the Basic Maps, displayed as an integral, over all relevant visual factor.

Second, this research is the indispensable instrument in analyzing the different "formal elements" (like single trees, solifluction forms, spectacular viewpoints, look-outs, etc.) to comprehend their influence on the motivation of groups of involved people. That qualification of landscape elements provides valuable information for future decisions about landscape development plans.

As derived from the Basic Maps, the Dominant Visual Landscape Map can show either abiotic features, biotic ground cover, man-made or influenced aspects of a combination of these.

Geology, Geomorphology, and General Relief Characteristics as Shaping Factors

The principal structure of every landscape is mainly caused by its mode of formation. Different crustal movements lead to differences in

elevation. Weathering, erosion and deposition of material then form the relief existing today. Each shaping factor leaves its specific features: weathering on bare rocks varies strongly from that on detrital slopes; or glacial cirques never look the same as a region of lateral or terminal moraines.

In this manner the following geological/ geomorphological criteria were taken into consideration:

a) main topographic features of the area (macro relief: canyons, gentle ridges, plains, etc.)
b) micro relief (areas with or without often changing relief: active or inactive geomorphic processes)
c) slope angles and combinations of them
d) structure and composition of the ground surface (bare rock, weathered or deposited material, etc.)
e) typical features, obviously telling about genesis (detrital fan, moraine, rockfall, etc.)

However, these criteria need only be applied if the resultant features really become apparent as dominant visual aspects in a certain landscape unit.

Forest, Other Vegetation and Human Impact as Shaping Factors

In addition to the abiotic features vegetation is in most areas also critical to the visual interpretation of landscape types. The following visual characteristics have been used to specify "Dominant Vegetation Landscape Types" in the Indian Peaks:

a) type of closed forest (conifers or leaf-wood)
b) density of trees (open/closed forest, timber line, clearings, etc.)
c) bushes (type, density, bushes along with other vegetation, etc.)
d) grass cover (type, density, along with other vegetation, impaired by geomorphic activity, etc.)

In many regions, human land use has become even more significant for landscape characterization than the natural vegetation. Not only have agriculture and forestry changed our environment but also road construction settlements, and, especially in alpine regions, tourist installations have produced an evident impact. In this sense there is a major contrast between the Aletsch Region and the Indian Peaks area, where the latter is more nearly unchanged by man (in the Indian Peaks human impacts are shown by the symbol $\mathcal{A}$, complementing dominant natural landscape units). The different vegetation features in the map of combined landscape types can be varied, but one visual aspect can generally be called dominant.

The Dominant Landscape Types (see Figure 3*).

The landscape type map of the Indian Peaks area is a combination of either dominant geological/geomorphological or dominant vegetation units or an association of both. In other areas like the Swiss part of the European Alps, man-made or influenced features would have to be taken into consideration much more. What does "dominant" mean in this case and how are these landscape types selected?

First of all, several maps have been compiled from air photographs and satellite imagery and from field work in the Swiss Alps, on the Swiss plains, and in the Indian Peaks. These maps are intended to show identical visual landscape types. First they are designated only by numbers, without mention of the different factors (geology, vegetation, etc.) producing different aspects. From these a large matrix of "abiotic elements versus vegetation elements" has been constructed. The following main landscape components have then been selected out of this matrix for a map of "Combined Dominant Visual Landscape Types" in the Indian Peaks. A prototype of the Combined Dominant Visual Landscape Type Map showing the region between Monarch Lake and the Continental Divide, Indian Peaks Wilderness Area, Front Range, Colorado, is displayed in the separate photo part of this paper as Figure 3*. This map displays only a small region of an area that is 200 square miles in size, and which has been determined to be the main study area for the forthcoming Indian Peaks Environmental Atlas. This kind of information is, as already mentioned, used in compiling the report about the suitability of revising the boundaries of the Rocky Mountain National Park.

Below Timber Line:

CO Conifers, closed forest; all abiotic features in that unit are less relevant than the "closed forest aspect."

AS Aspen, closed aspen area; all abiotic features and conifers are less relevant than the "closed aspen forest aspect."

CL Clearing in closed forest areas (either conifers or aspen), caused mostly by human impact (timber cutting, agriculture, etc.). No abiotic features are dominant because of surrounding forest.

ST Sparse forest areas, caused by moisture, human activities, or other factors (other than bedrock)

SR Sparse forest areas, caused by association with rock outcrops. "Forest impression" is still relevant. Comparable to FT.

LB Large valley bottom. Colluvial or alluvial area, at least 100 m large, mostly with creek

*See color illustration on page 388.

and relatively wet. Always covered by grass (forest in valley bottoms is mapped as "CO" or "AS").

CY Canyon or v-shaped valley. Strong downcutting by water; steep slopes, rough rock. "Forest aspect" not relevant.

Above Timber Line:

FT Forest-Tundra ecotone (tree-line zone). Mapped only if aspect of the forest below remains (if not look for units with the single trees symbol).

AV Alpine valley floor with typical high mountain character, mostly with large differences in relief downvalley.

GR Vegetated, mostly gentle ridges or slopes, covered by tundra (more dense than SS). Genesis: geological, periglacial, and/or solifluction; no big differences in relief, no boulder or large bedrock areas; detrital material visible in areas where the tundra is impaired.

SS Partly vegetated slopes. Some detrital material; slopes without large differences in micro-relief, covered with dense tundra ± (mostly less dense than GR); geomorphic movement partly apparent; no entire detrital slopes or block/boulder fields.

DS Detrital slopes or fans, mostly composed of material less than 50 cm in diameter; only very sparse vegetation possible because of heavy geomorphic activity.

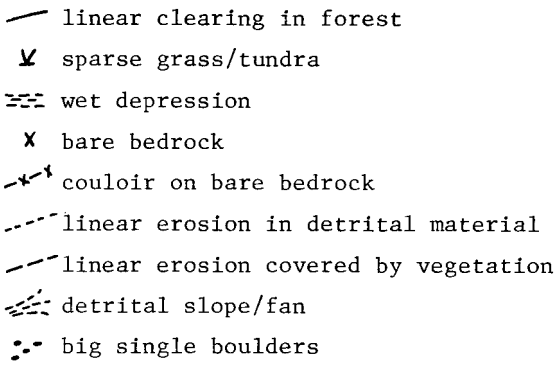
BF Block/boulder fields on slopes or plain surfaces, material greater than 50 cm in diameter. Genesis: rockfall, solifluction, or weathering in situ in big blocks; only sparse vegetation (less than 50% coverage).

BB Mixed bedrock bolcks and vegetation in between, large differences in micro-relief; either scoured by glaciers or the result of rough rock weathering.

RR Bare bedrock, rock walls or couloirs, mostly steep areas, rough weathering, no scouring ("climbing rock"); source areas of detrital slopes, or fans and boulder fields (rockfall).

GS Glaciers, or year-round snow.

So as to avoid losing too much detail and to have the possibility of mixing different features of the legend, several symbols (indices) have been added to specify the 13 dominant landscape types. These symbols represent only a selection of all the indices already used, and more may be added in the future:



The very thick black line on Figure 3 is the Continental Divide; the less thick shaded line shows tree line. All colors in red specify rock features; gray indicates accumulation areas; blue shows tundra; and green shows wood. The yellowish means a clearing, or open forest.

MOTIVATION RESEARCH TO DETERMINE THE VALUE OF THE DIFFERENT LANDSCAPE ELEMENTS

A Continuation of our Landscape Studies in 1979 and 1980

(Study Areas: Colorado and Switzerland)

A survey of people using the mapped areas will determine which landscape elements (from the Combined Landscape Type map) cause which kinds of response to the natural environment. This evaluation will show the planner which of these factors are most important in classifying the region as an estimable living or recreation area.

Next, the transformation of existing development plans (timber cutting, mining, roads, settlements, or tourist installations) into simulated, potential manifestations allows one to perceive visually how this environment could be changed. A second survey following this will provide even more detailed information about the real value of the various elements to the different groups involved. People will tell us which changes they accept and which they consider as a significant damage to the visual aspect of a scenic natural landscape. This approach to landscape aesthetics is a major input for management policy-making. In this way one should be able to consider which elements are especially sensitive, i.e., which elements must be protected under any circumstance to preserve an unmodified natural landscape. Only this preservation will retain the high value in the classification of a region. By means of the second survey we can also form some very interesting conclusions about possible reactions of inhabitants or tourists to unwelcome changes in the environment.

SIGNIFICANCE OF THE RESULTS: CRITICAL REFLECTION AND PROSPECT

Landscape maps make it possible to analyze and to characterize the environment from the visual and the aesthetic points of view. One learns a lot about the preferences of the different users concerning their classification of untouched natural landscape elements (positive and negative).

Through knowing the inventory of landscape features, and the expectations of inhabitants and visitors, as well as their reactions to landscape changes, one can provide useful information for landscape development and/or management policies in a given area. Such changes and policies should be accepted by all involved or interested people if they are to be successful. These results should then be used as a basis for planning and as a part of a "decision model" such as might be compiled by a group of researchers in the Swiss MAB 6A Program.

In addition, it is possible by collaboration with other scientists to contrast the evaluation of the visual aspects of landscape with economic and/or biotic factors. Every study pointing out stress limits in the socio-economic sphere or indicating "damages" in the natural ecosystem, would be related. This means that one would be able to prove if the different kinds of changes also are perceived by involved or interested people as exceeding a visual limit of landscape.

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