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Organized human society cannot exist without the basic resource of land to sustain and support it. Although we speak of food, shelter, and water as the essential commodities, all of these are derived from use of a land area. Furthermore, for several thousand years mineral raw materials have been an essential item for human society, and since they, also, are derived from the earth, their procurement is therefore another form of land use. Indeed, the concept of use of the land resource is so all-encompassing that it is difficult to consider any societal problem without in some way involving land use.

In spite of this universal dependence, the philosophical approach to the use of land has historically differed widely among the many human cultures. In some ancient and in some primitive societies, the land—that is, the earth on which we live and its indigenous plant and animal population—was held in great reverence. An ancient Sanskrit prayer expressed the concept in the phrase, "O, Mother Earth, ocean girded and mountain breasted, pardon me for trampling on you."

In America, the native Indians had a profound reverence for the land. Chief Joseph is quoted as saying: "...I never said the land was mine to do with as I chose." And, more than 100 years ago at a treaty parley in the northwest, another Indian leader said: "The Great Spirit, in placing men on the earth, desired them to take good care of the ground and to do each other no harm."

In contrast, western culture has generally viewed the land as being for the exclusive use of man, to be modified or exploited as the individual owner or the local society wishes at the moment. The contrast in attitude was eloquently stated a half century ago by Willa Cather:

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> When they left the rock or tree or sand dune that had sheltered them for the night, the Navajo was careful to obliterate all trace of their temporary occupation. He buried the embers of the fire and the remnants of food, unpiled any stones he had piled together, filled up the holes he had scooped in the sand....Father Latour judged that, just as it was the white man's way to assert himself on any landscape, to change it, make it over a little (at least leave some mark or memorial of his sojourn), it was the Indian's way to pass through a country without disturbing anything; to pass and leave no trace, like fish through the water, or birds through the air.

Against this historical contrast we must view present-day North America. The western practice of unrestricted land modification, if carried to an extreme, can result in modifications of one locality that seriously interfere with land use in an adjacent area. Land-use practice by a local group may prevent the larger society from making desired or necessary use of the land, including the production of food and raw materials. Such conflicts of land use have forced upon our collective consciousness the fact that, if our civilization is to survive, the use of land, particularly in the urbanizing areas, must be based on sound factual data and directed in such a way that it will not cause social deterioration. The numerical size of our population makes it abundantly clear that to support our citizens, even at a subsistence level, we are far past the point of return to the land ethic of the American Indian—even though there are those of us who wish that we could. The Honorable John D. Dingell underscored this fact when he stated, "You are not going to sell aesthetics to a starving Hindu."

Because our modern society cannot return to the ancient and primitive ethic of preservation of the terrain in its pristine condition nor continue in the western ethic of "do as you please to any parcel of land you hold in fee simple title," we must move to a position between these two, but quite different from either. We must say in effect that the owner of a parcel of land may use it for his own benefit as long as that use does not conflict with the overriding needs of the populace and of the nation and that, preferably, the use is compatible with the long-term needs and desires of the national culture.

I am not sufficiently presumptuous to contend that I can define the long-term needs and desires of our national culture, but I am convinced that those groups in our society that make such long-term decisions should base them on adequate scientific and technical data. Here enter geology, geochemistry, hydrology, geophysics, mineral-resource evaluation, and topographic mapping—all areas of knowledge, or activities, in which Geological Surveys have particular and extensive expertise.

We are here to take part in the dedication of the Reston National Center of the United States Geological Survey, and particularly of the John Wesley Powell Building of that National Center. This is indeed an appropriate forum for the discussion of the application of scientific and technical data to the wise use of our land resources. Major Powell was a giant among pioneers, not only in scientific exploration but also in the development of governmental agencies that made possible the generation of data in a context where it could be useful to public decision makers.

Now, let us take a brief look at techniques available to attack this broad, basic problem, and at the directions that may be taken in the future.

The geological sciences, in all of their applied branches, must be called upon to furnish the information needed for evaluation of our basic land resource. Many of the applications are obvious and have been described repeatedly and at length. Mapping of the topography and of the surficial geology clearly is part of the first step, because many of the essential features are derived from these basic elements and can be understood only in the context of such background. The distribution and lithologic character of the earth materials at the surface, and to depths of as much as 50 feet, have a direct bearing on virtually any human use of the land. However, it is not enough merely to map the distribution of the formally described rock-stratigraphic or time-stratigraphic units. The mapped units must be characterized as to their lithology, mineral composition, engineering properties, hydrologic characteristics, and lateral and vertical variability, and there must be indication of the rock type immediately underlying. The surficial soils that have developed on the described deposits should be mapped from the standpoint of their physical properties as well as their agricultural utility. Each of the materials units that has been mapped should be evaluated as to its suitability for the many specialized uses that can be made of a particular parcel of land—be it for construction of residences, large buildings, or highways, or for recreation, waste management, mineral resource development, agriculture, or other use.

The type of map evaluation described is almost universally needed to determine what use of the land would be most beneficial to society. However, this basic evaluation is only the beginning of the application of the geological sciences. Essential in some areas, and for some uses, are a wide range of specialized data that may pertain to rocks hundreds or thousands of feet below the surface. Examples of these supplemental data are the presence or absence of aquifers containing ground-water supplies and the quality and abundance of such potential water supplies; the presence and distribution of former or active underground mining that might at some time affect the use of the land surface; the character of deep rock units that are potentially useful for the safe disposal of liquid wastes; the seismic characteristics of the area, which can be used to evaluate earthquake hazard; and, of great future importance, the location and character of mineral resources that have potential for development so that their availability can be protected until they are needed. This last point is particularly relevant in the vast reaches of public land in the western half of our nation, where we have been moving from an early policy of "free-for-all" for mineral claims and exploitation toward a policy of preservation, but without accurate and detailed knowledge of the potential mineral resources that may be needed desperately at some future time.

The future availability of mineral resources is a problem that illustrates the importance of the concept of multiple-sequential use of land. If an area of important mineral resource that has the potential to fill future needs is identified, the first phase of land use might be for recreation, for "open space," or for conservation. The first phase can then be followed by a second phase of mineral production, after which a possible third phase could be devoted to waste disposal, urban development, agricultural production, or recreation, as the needs of society at that time might dictate. The concept of multiple-sequential use of land is not new, and in fact it has on occasion been practiced by accident. In the future it should be practiced by deliberate intent, but it must be based on sound, detailed information about the mineral resource involved and the suitability of the subsequently disturbed area for a third phase of use.

This last phase clearly indicates the need for continuing research on the problems of reclamation or restoration of disturbed land areas.

As our social structure becomes more complex, and as we become increasingly more dependent upon the products of science and technology, we require increasingly sophisticated data on which to base decisions for the specialized uses of our land resource. This is well illustrated by the area of waste management. Solid waste is generally contained in sanitary landfills, which is a specialized form of land use. Landfills, which now occupy only a very small segment of the land area, have a potential side effect—the pollution of water resources that may move far beyond the site. Research on the leachates from landfills and the resultant potential for pollution is only starting at a few places, but it is an area of research that needs vigorous support in the near future from the earth science agencies of the Federal Government. The effluent from landfills contains an amazing mix of potentially toxic trace elements and deleterious ions derived from the refuse in the landfill. Basic research is required to determine which and how much of the many potentially toxic constituents will be carried outward from the fill into the regional terrain to become a potential pollutant of the regional water supply, or will remain trapped in the surrounding sediments. Such research, although considered by some to be pure science, is essential to our social existence in the near future. The hydrologic system through the landfill is as important as the geologic parameters that influence the circulation of fluids. Hydrologic data are also essential in evaluating the potential effects of injection of liquid industrial wastes into deep rock layers.

Land use may be importantly influenced by a group of natural phenomena that have been loosely called "geologic hazards." They include ground movement associated with earthquake shocks, unstable ground and potential surface movement, episodic flooding, accelerated shore erosion, and potential volcanic activity. At least some research is under way on all of these problem phenomena. The best available information on these potential hazards must be part of the background data on which land use decisions are based.

An aspect of the land-use resource that has been generally disregarded is the societal use of subsurface space. Although airspace above the land surface has been generally, and legally, regarded as being within the realm of public allocation, the use of volumes of space below the land surface has been considered subject to public control in only a few special circumstances. In our metropolitan areas, the use of subsurface space is becoming a societal problem. Subways, sewers, water mains, and service access have for years been normally situated underground in metropolitan areas. However, use of the subsurface for such purposes competes with ground-water supply, waste disposal, wastewater conveyance and storage tunnels, mineral resource development, and underground storage of commodities, and presents a problem that has been given neither legal nor public consideration. It is to be hoped that, before future decisions are made on the allocations of subsurface space that might permanently render it unusable for any other purpose, the earth sciences will be asked to provide the technical facts that should be background to any political decision on the subject.

In an analysis of land use we must consider such problems as reclamation of strip-mined land; possible future subsidence of undermined land; regional effects of canalization, artificial impoundments, and levee construction along major rivers; and the conversion of vast acreages of agricultural land to urban use. The effects of such actions have long been predicted by earth scientists but, unfortunately, the implications of future effects commonly have not been a component of the decision-making process. Furthermore, continuing research is clearly indicated. For example, we know more about effective procedures for reclaiming shallow strip-mined land with relatively gentle slopes and an original cover of unconsolidated Pleistocene deposits than we do about techniques of preventing surface subsidence in undermined areas.

Having considered the areas in which earth scientists should furnish needed data to guide the political decision makers in the use of our limited resource of land, we might briefly consider new techniques available to achieve their needed goals. Most of the approaches used by the geologist, geochemist, geophysicist, and hydrologist are well established, but new techniques of data gathering and predictive capability are constantly evolving. One of the major technologic changes is in our ability to analyze smaller and smaller quantities of potentially toxic substances. Publicly acceptable tolerances tend to follow our ability to detect. As the level of our chemical and mineralogical analytical capability increases—particularly our ability to detect trace quantities—we as a society tend to become conscious of possible hazards and consequently tighten our standards of acceptance until all tolerance disappears. In the wise use of our land and water resources, we must be aware of the fact that if we place our standards of acceptance beyond the level that existed before modern human societies occupied an area, we are being ridiculous. As a former Director of the United States Geological Survey has pointed out, nature's normal functioning is the world's greatest polluter. Clearly, therefore, an important area of basic research is the establishment of "background" data—that is, the determination of the levels at which the many constituents existed in the environment before the advent of western culture. Furthermore, the concept of zero tolerance—that is, zero discharge to the environment of the products of human activity—is totally unrealistic. We must determine instead what level we can tolerate.

New technologies have recently developed that can aid the earth scientist in fulfilling his needed role of delineating and analyzing for the decision makers the factors involved in our land resource. Prominent among these are remote sensing, including sensors on satellites, and computer manipulation of data. Other new and exotic techniques will develop through time. But it should be remembered that these are only new "tools of the trade," to aid in achieving the needed results. In themselves they do not alter the problem or the basic data that are needed by the political decision makers.

In conclusion, let me return to the basic problem with which I started. As Preston Cloud stated in 1971, "Nothing can increase infinitely on a finite Earth....food and raw materials place ultimate limits on the size of populations." The demands and needs of today's increasing population require that we depart from the philosophies of earlier cultures—be they ancient, primitive, or western—in their approach to the use of our land resource. Social decisions for land use must, in the future, be based on the best and most reliable information that our public decision makers can obtain. We can no longer afford whimsical or emotional decisions, or decisions based on vicious self-interest. Earth scientists must use all of the developing and advanced technology available to furnish our public administrators with the needed data. And, in turn, governmental bodies must support the acquisition of that needed data—at federal, state, and local levels—by encouragement and funding, and they must heed the data that are available to them in their formulation of public policies.

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