Soil potentials: A positive approach to urban planning

Looking at soil properties in terms of their potentials rather than limitations is more likely to result in land use plans that are compatible with a community's needs.

DONALD E. McCORMACK

BETWEEN 60 and 65 million acres or about three percent of our land is now in urban use (*8*). This includes land used for transportation systems. There are roughly 150 million urban residents, so the amount of urban land used per urban resident is about 0.4 acre. We are now cultivating 2.1 acres of cropland per capita.

It seems almost incredible that the span between these two figures is as narrow as it is. Certainly it is a tribute to the productivity of the American farmer and the soil he tills. It is made even more impressive by the fact that the value of our farm products exported in 1973 was nearly $19 billion or almost $400 for the average family of four.

In the next 30 years it is estimated that 18 million acres of land will go to urban uses other than transportation (*10*). Each decade, an area larger than the state of New Jersey will be urbanized.

A question vitally important to all Americans is what land should be used for urban development? How we answer that question will determine in a large measure the quality of life and the productivity of the land for all uses in the future. Decision-makers, both in the market place and in city hall, must face this question by carefully studying the long-term consequences and economic, social, and environmental impacts of land use changes (*1*). The nature of our soils—their limitations and their potentials—is one of the key considerations in answering this vital question.

Soil Limitations

For more than 10 years, extensive use has been made in urbanizing areas of the detailed information provided by soil surveys. To a large degree this information has been used to identify soil limitations that impose hazards to the intended urban use. Where such information was not used, many urban residents have encountered serious problems with their homes. Failures of septic tanks systems, wet basements, cracked foundations and walls due to unstable soils, and flooding are costly problems that plague many homeowners.

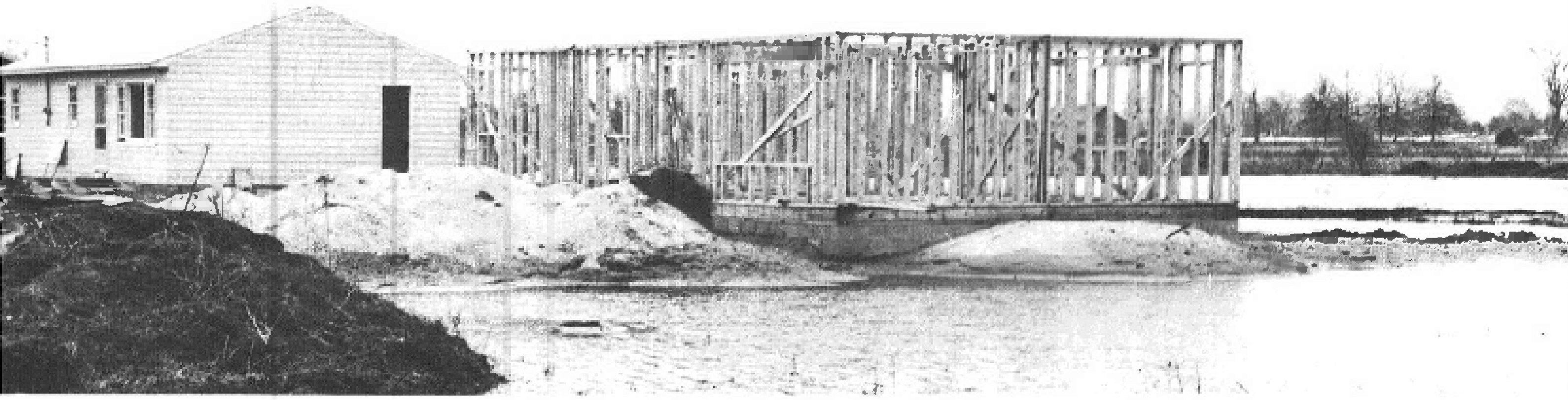
These soil-related problems are a result of soil properties that prevent proper performance. The problems could have been anticipated and measures taken to minimize failures if information about the soil properties had been available.

Planning commissions, health departments, highway departments, local governments, builders, developers, and others are increasingly aware of the value of soil data in making decisions. Copies of soil survey field sheets, interpretive tables, and maps and published soil surveys are used directly by many of these agencies and individuals. Also, an increasing number of communities have arranged for a technical review by the local soil conservation district of all requests for proposed developments. A principal part of this review is reference to the soil data and consideration of soil properties that are likely to impose hazards on the intended use.

Most often this activity is oriented toward avoiding problems, and there are many outstanding examples where this approach has proved valuable. Most advantages of using soil survey data in urbanizing areas that Klingebiel (*12*) listed in determining a highly favorable benefit-cost ratio (125:1) were of this nature. The fact that an area has a severe soil limitation for basements and septic tank absorption fields due to a high seasonal water table may be among the planner's most powerful arguments against a proposed development.

The process of pointing out problems is often immediately effective for the same reason that a blind man appreciates knowing there is a cliff three steps ahead of him. We may have little

Donald E. McCormack is assistant director of the Soil Survey Interpretations Division, Soil Conservation Service, U. S. Department of Agriculture, Washington, D. C. 20250.



Soil Conservation Service photo by Antonides

chance to influence his resolve to walk off the cliff, if in fact he has chosen to do so, but fortunately he usually wishes to avoid disaster.

Land Use Regulation

Increasingly, devices other than zoning are being used to restrict land use. Denial of permits for septic tank absorption systems due to slow soil percolation rates, coupled with decisions not to extend sanitary sewers into selected areas, is proving effective. Tax policies have been legislated in many states to provide relief for farms near developing areas (*9*). Purchase of development rights or their optional donation to the community, as near Yellow Springs, Ohio, is receiving more attention.

Where building is done on soils with severely limiting properties, some communities are passing ordinances that require special designs to minimize the poor performance that resulted when standard designs were used. The village of Canfield, near Youngstown in northeastern Ohio, received an innovation award in 1973 from the International City Management Association for its subdivision regulations that vary the design requirements for houses according to the kind of soil as indicated by soil surveys (*2*). The design of basement walls, including the use of pilasters and reinforced concrete, to resist high shrink-swell; of wider foundation footings for soils with low strength; of special drainage practices for basements; of limits in depth to the basement floor; and of street pavements in subdivisions are based on the kind of soil (*6*). Considering the vast amount of information provided by soil surveys, it seems incredible that many building codes still require the same design for the above elements of home construction for all homes built within their jurisdiction, giving no consideration to the wide range of unique kinds of soils that occur there.

Zoning has been considered a valid exercise of the police power of government, whereby the public health, safety, and welfare are protected (*13*). In the recent Wisconsin case of Just v. Marinette County, the courts upheld zoning based on the eminent domain power of government, claiming that eminent domain is exercised when the government wishes to restrict a person's use of his land to secure an affirmative benefit for the public (*13*). The Justs, who were prevented from filling a marsh, were denied the compensation usually provided in cases of eminent domain. The court held that the only value to be considered in determining the compensation is that based on the use of the land in its native state. It will be very interesting to see how this decision affects the application of zoning in the future.

Maximum Net Productivity of Land

At any point in time, in spite of our inability to specifically define it (or achieve it), there exists that unique set of uses of available resources that results in the maximum net productivity of land. The naturalist, the farmer, the developer, and others have their own ideas about what the priorities should be.

Complex as its solution may be, there exists a formula for weighing and integrating the many opinions and factors that impinge on this issue. Most people would agree that maximizing alternatives for future use should be included and given considerable weight in such an equation.

Too vague, too complex, too hypothetical, too idealistic—these are common reactions to the above definition of maximum net productivity of land. Defined in these terms, productivity is so interwoven with the aspirations of people that many social objectives are inseparable from the obvious economic implications. Crazy Horse, the great war chief of the Oglala Sioux, was quoted as saying, "One does not sell the earth on which the people walk" (*15*). The concept of property and the rights that go along with its ownership will, of necessity, gradually change as the needs of an increasing population impact on dwindling or at least finite resources.

Environmental quality has been considered diametrically opposed to increasing levels of production or development by most conservationists. It is painfully obvious that in many cases progress, as normally defined, has come at the expense of environmental values.

When changes are considered in the use of soils or other resources, ways should be sought to minimize the degradation of air quality, water quality, and other aspects of the environment. The choice of which land to use for given kinds of development is in most cases a vitally important determinant of the impact on environmental quality. The study of ways to design a development on given kinds of soil to minimize adverse environmental impacts also is needed, both before a site is selected and as plans are made for its development.

In the long run there is no way that the net productivity of land can be maximized without also maximizing environmental quality. Each new project that is built without properly taking into account environmental quality will result in unnecessary pollution or deletion of values that will subtract from the maximum net productivity of the land.

Odum (*14*) defined ecosystems as areas of nature that include living organisms and nonliving substances interacting to produce an exchange of materials and energy between the living and nonliving parts. Increasing emphasis is being given to the consideration of ecosystems in land use planning, especially by environmentalists. Many environmental values can be maintained if existing ecosystems can be preserved or properly managed. However, many people who define and interpret ecosystems do not give proper weight to the soil that sustains them.

It is interesting that in his discussion of ecosystems, Odum (*14*) cited the most striking contrast between a pond and a terrestrial ecosystem as being the size of green plants. Perhaps statements such as this result in the lack of proper attention to the difference in the sustaining medium among many who apply these concepts. Odum later referred to soil as a highly developed ecological subsystem that determines the nature of terrestrial ecosystems.

It is estimated that about 95 percent of the living organisms sustained by soil are within the soil rather than above the soil surface (*5*). There are about 100,000 different kinds of soil in the United States (*17*). No two of these soils have exactly the same combination of the five factors of soil formation—parent material, climate, living organisms, relief, and time or age. Because most of the factors that determine the native terrestrial ecosystems are controlled by the soil, and in fact most living organisms making up the ecosystems are within the soil, any definition of the term that does not include the kind of soil as a central feature is incomplete.

The same kind of soil obviously may support several different kinds of ecosystems, depending on what man has done with the land. The best prospect for predicting the impact of man's action on ecosystems is to evaluate the nature of the soil before the action takes place, determine the soil properties that will influence the ecosystem after land use is altered, and predict the nature of the ecosystem after the change is made. Often it is possible to examine land nearby where a similar change in use was made on the same kind of soil and with the same vegetative community to verify this prediction. Kinds of ecosystems have little interpretive value unless the kind of soil is included in their definition.

Positive Approach to Urban Planning

The outlook for continuing success in urban planning over a long period of time is much greater when the effort is centered around the positive objective of maximizing the net productivity of the land rather than around the objective of avoiding problems or nuisances. Evaluation of alternative plans, each of which portrays attempts to use available resources to their potential, is most likely to result in plans that are compatible with a community's needs.

There is a tendency for planners to speak of soil suitability when they discuss the merits of various land use proposals (*3*). Usually they are equating soils with severe limitations to poorly suited soils and soils with slight limitations to well suited soils. In some urban areas such a conversion of terminology is valid. For many areas it is not.

For more than 10 years soil interpretations for nonfarm land uses have been presented largely through the identification of the degree and kind of soil limitation. Presentation according to soil suitability was rejected for several reasons. Foremost among these reasons were (a) the fact that a site's overall suitability is determined by a great many things other than the nature of the soil, (b) an awareness that soil limitations can be overcome by proper design, and (c) the lack of extensive data about the performance and cost of potential practices for overcoming soil limitations in specific kinds of soil.

As a result of presenting interpretations on the basis of limitations, the use of soil data has been incomplete. An analogy to conservation planning for a farm illustrates the problem.

Suppose a conservationist visits a farm, discusses the farm's conservation needs, and presents alternatives showing the farmer the importance of conservation treatment and wise use of his land. Referring to the soil survey, the conservationist points out to the farmer that a sloping soil is highly erodible when it is used for cultivated crops. He also points out a nearby area of nearly level soil that would be better for cultivated crops because there would be little erosion, but he notes that it has a severe wetness problem. About this time the dialogue ends, and the farmer is left to determine how he should use the facts given to him. Indeed, this is a very incomplete approach to conservation planning if we assist the farmer no further, yet in many cases we go no further in assisting the urban planner or other officials of local government.

Soil potentials provide a positive basis for proceeding through the application of facts about soil properties and limitations to planning for specific objectives. Planners seek ways of fitting the growth of urban areas to the limitations of the environment (*3*). Where it is feasible, economically and environmentally, to overcome limitations to meet the needs of society, it may be logical to use soils for a given purpose for which they have severe limitations. The principle is followed in conservation farm planning. It is one of the basic assumptions in the land capability system, in which the capability class is assigned on the basis of continuing limitations after the application of feasible practices (*16*). Much of the nation's corn crop is produced on soils that in their natural state have severe limitations for growing corn.

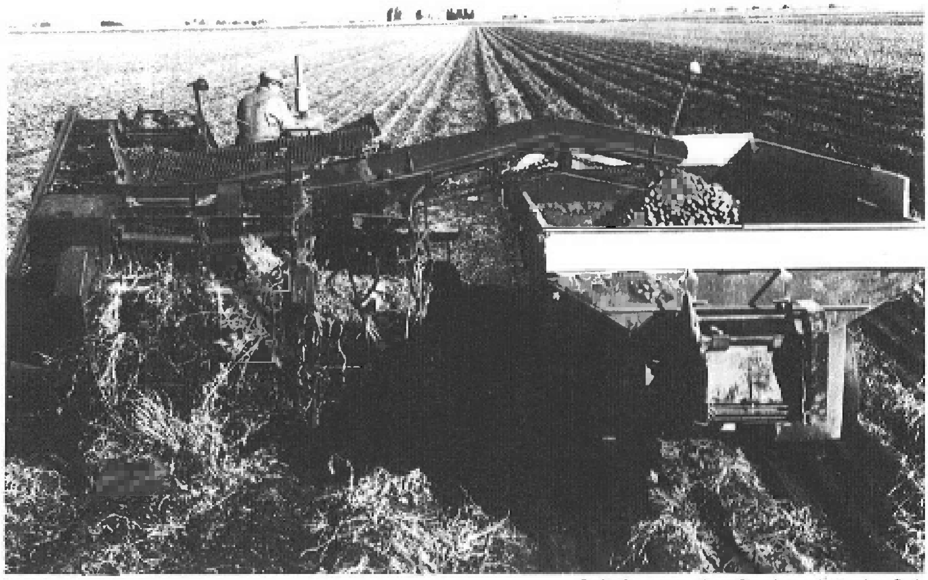
Soil potential has been defined as the ability of a soil to produce, yield, or support a given structure or activity at a cost expressed in economic, social, or environmental units of value (*11*). As previously indicated, among the various kinds of inventories of natural resources, the soil survey has the highest interpretive value for most aspects of urban planning. If we define the kind and extent of man's activity, we can predict the ecosystem, the amount of runoff and erosion, and most other of the elements that determine environmental quality and productivity.

In determining soil potential it is essential that the practices that might be used to overcome the soil limitations be identified, as well as their cost and an estimate of any continuing limitation after they are installed. This procedure is used with the farmer in the above example when the alternatives of contouring, stripcropping, or terracing are considered so that cultivated crops can be grown on the sloping soil.

Increasing data are available on practices that can be used to overcome soil limitations for nonfarm land uses. For example, use of perimeter drains around absorption fields can improve the function of septic tank systems on some soils with seasonal high water tables (*4*). The "Texas slab" can be used on soils with high shrink-swell potential to assure stable foundations, or steel-reinforced concrete basement walls can be used in such soils (*6*). Basements can be eliminated altogether, provided with increased drainage, or placed at a shallower depth in wet soils.

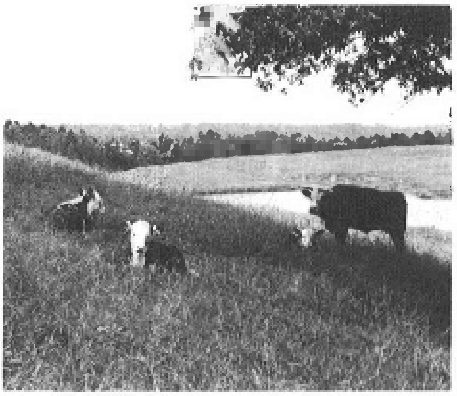
It is not possible to completely weigh the alternatives in land use until the full range of such practices is identified. Identification of these practices is necessary before an array of soil potentials can be developed, a task that should be given high priority in the next few years. Local information about "what works" in overcoming soil limitations must be recorded by kinds of soil.

For many communities, it is not



Soil Conservation Service photo by Cole

Some soils, such as this organic muck soil, have excellent potential for farming but poor potential for housing and similar developments.

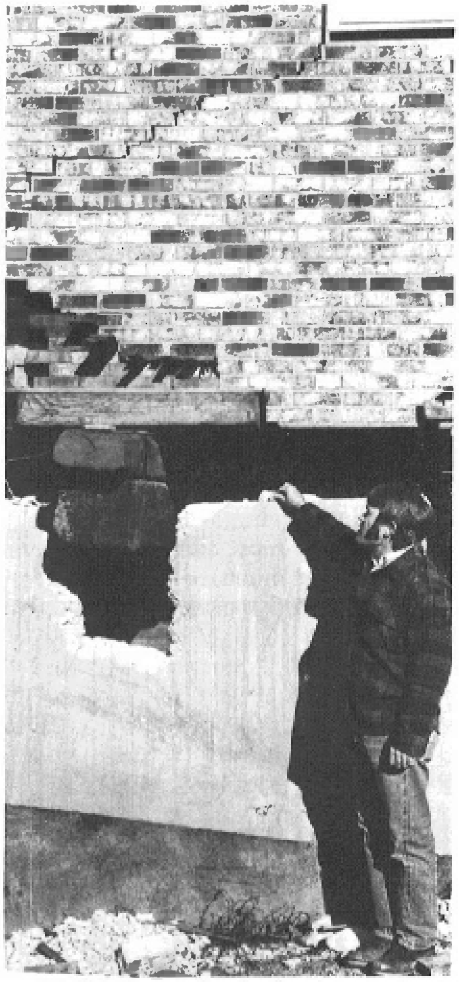


Soil Conservation Service photo by Earle

Sloping soil with a good potential for pasture may have a poor potential for housing because of the erosion hazard.

Soil Conservation Service photo by Cole

Gullying threatens this home because the community's building code did not adequately consider soil stability in specifying design criteria.



Soil Conservation Service photo by Mapes

Building on soft organic soil resulted in this subsidence problem. Use of soil surveys can prevent the use of such soils for houses and other buildings.

physically or socially possible to locate all urban development on soils with slight limitations for the required land uses. In fact, in some communities all the soils may have severe limitations for some kinds of urban development. For example, all the soils around New Orleans, Louisiana, have severe limitations for dwellings due to flooding, high water tables, or unstable soils. Some soils, however, are much more favorable than others.

Obviously there will be no moratorium on building homes in the New Orleans area because of these limitations. Local builders have found ways of providing protection against flooding; they provide drainage; and they design foundations that will support the loads. By Ohio standards these practices are prohibitively expensive, but it is not necessary in Ohio communities to build on soils with such severe limitations.

Some wet soils in the New Orleans area are much wetter than others. Some unstable soils are much more unstable than others. Some soils flood much more frequently and more deeply than others. By evaluating the limiting soil properties and considering the relative cost of overcoming the limitations, it is possible to identify those soils best suited for building and those least suited. All the soils in the area can be ranked in terms of relative suitability; and through this ranking, soils best suited for building homes can be identified. Even though these soils may be more limiting than the poorest soils in some Ohio communities, such a ranking of soil potentials is a powerful tool in planning.

Fortunately most communities have soils that are much better suited for building than those in the vicinity of New Orleans. But for these communities it is still important to develop a ranking of soil potentials. Assume, for example, that all soils have slight limitations for building. Depending on local objectives, some of these soils might be considered poorly suited for building because they are highly erodible during construction, because soil reaction is not acid enough to grow the azaleas prized by the local residents, because they are too coarse in texture in the lower horizons to properly filter effluent from septic tanks, because they are highly productive for important cultivated crops, because they are ideally suited for intensive recreation sites, or for many other reasons.

It is essential that local objectives be listed, discussed thoroughly, and agreed to before the task of developing an array of soil potentials begins. Such an activity is a logical function of the local planning organization, as is the ensuing ranking of the soils, and it cannot be separated from local objectives if it is to be useful.

This approach has been called edaphic planning (*11*). The professional planner who elects to follow this approach can expect to obtain a wide scope of support and assistance from conservationists, natural scientists, citizen groups, and individuals concerned about the quality of the environment. Assistance from the soil scientist and soil conservationist, as well as the engineer, sanitarian, biologist, and related professions, will be required to develop the most meaningful array of soil potentials.

Application of soil potentials to planning in areas broader than the local community also holds promise as a tool for fitting land use plans and policies to limitations and potentials of the environment. Councils of governments covering several counties can make good use of an array of soil potentials, along with a generalized soil map covering the counties, in planning for transportation networks, waste disposal systems, park and recreation systems, preservation of prime farmland, and other elements of land use. There are now 328 such councils in the United States (*7*). Likewise, state governments, multistate regions, and the federal government can make extensive use of soil potentials.

At each level the ratings of soil potentials for individual kinds of soil must be relative to all other soils in the area covered. Soils rated poor in a few local communities may be fair or good in the larger region or vice versa. As in developing such arrays for local communities, it is necessary that objectives in land use for the large areas be identified.

Conclusion

It is not inevitable that our cities grow as massive amoebae, spreading across the land, eliminating irreplaceable resource potentials, and creating serious environmental problems with fingers of strip development or colonies of leapfrog development that limit the alternative future uses of large areas of land. Soil potentials provide a valid basis for a positive approach to making land use decisions that will help insure the best use of the vast land resources of this country. Through use of the soil potential concept, such planning will help achieve the maximum net productivity of the land—a worthy goal for us all.

REFERENCES CITED

1. American Assembly. 1974. *Land use in America.* Report of the 45th American Assembly, Harriman, N. Y., April 1974. Columbia Univ., New York, N. Y.
2. Baker, W. B. 1973. *Soil surveys—a base for building codes.* Public Manage. (May): 9-10.
3. Bauer, K. W. 1973. *The use of soils data in regional planning.* Geoderma 10: 1:1-26.
4. Bouma, J., W. A. Ziebell, W. G. Walker, P. G. Olcott, E. McCoy, and F. D. Hole. 1972. *Soil absorption of septic tank effluent.* Inf. Circ. No. 20. Dept. Soil Sci. and Bact., Univ. Wisc., Madison.
5. Buckman, H. D., and N. C. Brady. 1969. *The nature and properties of soils.* Macmillan Co., London, Eng.
6. Canfield Planning Commission. 1966. *Canfield subdivision regulations.* Canfield, Ohio.
7. Croke, E. J., K. G. Croke, A. S. Kennedy, and L. J. Hoover. 1972. *The relationship between land use and environmental protection.* Joint Rept., President's Water Pollution Control Adv. Bd., and Air Quality Adv. Bd. Washington, D. C.
8. Frey, H. T. 1973. *Major uses of land in the United States: Summary for 1969.* Agr. Econ. Rept. No. 247. Econ. Res. Serv., U. S. Dept. Agr., Washington, D. C.
9. Hady, T. F., and A. G. Sibold. 1974. *State programs for differential assessment of farm land and open space.* Agr. Econ. Rept. No. 256. Econ. Res. Serv., U. S. Dept. Agr., Washington, D. C.
10. Jackson, Sen. H. 1974. *Speech introducing proposed land use bill to the Senate.* In *Land Use and the Environment: An Anthology of Readings.* Am. Soc. Planning Officials, Chicago, Ill.
11. Johnson, W. J., and L. J. Bartelli. 1974. *Rural development: Natural resource dimensions.* J. Soil and Water Cons. 29: L:18-19.
12 Klingebiel, A. A. 1966. *Costs and returns of soil surveys.* Soil Cons. (August): 3-6.
13. Large, D. W. 1973. *This land is whose land? Changing concepts of land as property.* Wisc. Law Rev. 1973(4): 1,039-1,083.
14. Odum, E. P. 1971. *Fundamentals of ecology.* W. P. Sanders Co., Philadelphia, Pa.
15. Sandoz, M. 1945. *Crazy Horse, the strange man of the Oglalas.* Knopf, New York.
16. Soil Conservation Service, U. S. Department of Agriculture. 1966. *Land capability classification.* Agr. Handbook No. 210. Washington, D. C.
17. Soil Survey Staff, Soil Conservation Service, U. S. Department of Agriculture. 1974. *Soil taxonomy: a basic system of soil classification for making and interpreting soil surveys.* Agr. Handbook No. 436. Washington, D. C. □