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The enactment into law of the "principle of multiple use" in the Multiple Purpose Forest Act of 1960[1] reminds us that much thinking concerning choice of resource use is based upon very rough understandings of the process by which choice is exercised. In the national forest operations, for example, multiple use has been a watchword of administration since the earliest days of federal activity,[2] but there has been relatively little attention to the way in which either private operators or public servants arrive at schedules for using particular pieces of forest land in particular ways.

The 1960 Act defines multiple use to mean:

> The management of all the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output.

This is an extremely difficult task, especially when there is sparse knowledge of the factors that are at work in setting present uses and of the effects of such use.

It is easier to specify what would seem a wise combination of uses for a forest unit in the light of physical research and national aims than to determine the process of choosing present uses, and, indeed, as McConnell[3] and McKinley[4] have pointed out, there may be administrative advantage in having a vague charter and a flexible method in applying public policy where the special interest groups are thorny and sometimes incompatible.

It has been common to advocate multiple-use of water resources since the Inland Waterways Commission and the National Conservation Commission ad-

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1. Multiple Purpose Forest Act, 74 Stat. 215, 16 U.S.C.A. §§ 528-31 (Supp. 1960).
2. Hays, Conservation and the Gospel of Efficiency (1959).
3. McConnell, The Multiple-Use Concept in Forest Service Policy, Sierra Club Bulletin, 195—, p. 14.
4. McKinley, Uncle Sam in the Pacific Northwest 317 (1952).

vanced their broad aims.[5] The view held by many workers in public service has been summed up simply by the Commissioner of Reclamation as follows:

> Sound water resource development is not limited to irrigation and hydroelectric power. Other purposes deserve adequate consideration, and facilities, therefore, should be constructed when shown to be economically justified. These other purposes include flood control, navigation, municipal and industrial water supplies, pollution and salinity control, protection of public health, enhancement of recreation potentialities, and preservation and propagation of fish and wildlife.[6]

What were for many years crude attempts to establish economic justification for water projects have been refined by the highly fruitful work of Eckstein,[7] Hirshleifer,[8] Krutilla,[9] McKean,[10] Wollman,[11] and others who have advanced analysis of the efficiency criteria for public investment. This goes far beyond the thinking when the Federal "green book" first attempted to formulate uniform methods of project evaluation[12] although it has not yet had a major impact upon federal policy. We now have keener tools for estimating optimal combinations of complementary water uses which permit sharper judgment of uses in terms both of contributions to national product and of income re-distribution, and which also allow for difference in timing.

These improved methods of weighing various resource allocations nevertheless leave much to be desired in explaining present allocations and in indicating the conditions in which wiser allocations might be achieved. Considerations of economic efficiency may not be determining factors. One of the pervasive problems in resource management today is the widening gap between practice and knowledge.[13] Many forest lands are operated at far less than what is optimal use for production; efficiency of water use by either economic or physical criteria is low. This requires explanation in terms that both state the problem and point to possible solutions.

In an effort to find a general method of analysis which would help describe actual choices in resource use and promote systematic appraisal of possible new uses, I have experimented with several approaches. The broad formulations of

5. Conservation Comm. Report, Vols. 1 and 2, S. Doc. No. 676, 60th Cong., 2d Sess. (1908-1909).

6. Address by Floyd E. Dominy, World Power Conference, in Madrid, June 5-9, 1960.

7. Eckstein, Water Resource Development (1958).

8. Hirshleifer, De Haven and Milliman, Water Supply (1960).

9. Krutilla and Eckstein, Multiple Purpose River Development (1958).

10. McKean, Efficiency in Government Through Systems Analysis (1958).

11. Wollman, The Value of Water in Alternative Uses (1961) (unpublished in hands of author at The University of New Mexico).

12. U. S. Inter-Agency Comm. on Water Resources, Report on Proposed Practices for Economic analysis of River Basin Projects (Rev. 1958).

13. White, Alternative Uses of Limited Water Supplies, 10 Impact of Science on Society 243 (1960).

Ackerman,[14] Zimmerman,[15] and others concerning the relation between levels of living and natural resources have been helpful. So also have been the decision-making schema of Banfield,[16] Firey,[17] Lee,[18] Simon and March,[19] and the Sprouts.[20] From work with problems of flood-plain occupance, water use, and recreational land use, a framework for describing resource decisions has emerged which is presented here for discussion. It will be stated briefly, and its possible application will be illustrated by detailed reference to flood-plain use and by passing reference to prevailing policies of national forest and water management.

I. MANAGERS AND ESTABLISHMENTS

In this analysis decision making affecting natural resources will be considered as centering upon managers who are responsible for establishments. Managers are defined as the individuals, including corporations and government agencies, who act as a unit in the management of an establishment. An establishment is defined as a single residence, agricultural, commercial, manufacturing, transportation, or public service organization that has a distinct usage of area. Examples of establishments would be a city residence, a ranch, a shop, a manufacturing plant, a national forest, a county and a government dam. Examples of managers for such establishments would be a city dweller who rents or owns a house, a farmer, a merchant, the board of directors of a manufacturing company, the regional office of the Forest Service, the county zoning board, and the bureaucracy of a government agency. The manager, so defined, may be either an individual or a group. There are, of course, situations in which the responsibility is divided, as between a legislative body and an administrative officer, or is shared, as between a land owner and tenant.

Ownership is not a necessary attribute of a manager. He may be a farmer who wholly owns his land, a tenant owning no interest in the land but enjoying the privilege of using it as he pleases, or a government bureau following general policies laid down by a legislative body.

The size of an establishment may vary from a fraction of an acre, as in the case of many city dwellers and small-scale farmers, to thousands of acres, as in the case of large ranchers, timber corporations, and government land and water-development agencies.

14. Ackerman, Population and Natural Resources, in The Study of Population 621 (Hauser & Dudley ed. 1959).

15. Zimmerman, World Resources and Industries (1933).

16. Banfield, The Decision-Making Schema, XVII Pub. Admin. Rev. 278 (1957).

17. Firey, Patterns of Choice and the Conservation of Resources, 22 Rural Sociology 113 (1957); Firey, Coalition and Schism in a Regional Conservation Program, 15 Human Organization 17 (1957).

18. Lee, Optimum Water Resource Development (Calif. Agricultural Experiment Station Mimeo. Rep. No. 206, 1958).

19. March and Simon, Organizations (1958).

20. Sprout, Harold and Margaret, Man-Milieu Relationship Hypotheses in the Context of International Politics (Center of International Studies, Princeton 1956).

Establishments also may overlap. An irrigation farmer may be fully responsible for the use of his own land subject to a county zoning ordinance, but belong to a water district where the responsibility for distribution of water is shared by an elected district board. And in the same instance he may have sold the mineral rights to oil underlying his land and be subject in his summer grazing operations to decisions by the regional forester.

II. RESOURCES, ADJUSTMENTS, USES, AND MULTIPLE-USES

A resource is culturally defined. It is considered as an aspect or combination of aspects of the natural environment suited to some human use. Whether resources are described by physical classes—soil, water, minerals, and the like—as in the traditional conservation literature, or by areal combinations, as in the tradition of much geographic study, they may be regarded as being delimited by human assessment of possible use. Such use may be for a single purpose or for complementary purposes, and for any given purpose the resource manager may employ some variety of adjustments of technology and managerial methods to achieving that use. Thus, given a piece of land with a homogeneous forest stand, the manager may use it for timber alone or for various combinations of uses, but he also may adjust his technology, such as logging methods, and his management system, such as timing of harvest, in several ways to reap the returns he seeks. It is helpful to think of there usually being several possible kinds of adjustments by which a given use may be realized.

Notwithstanding widespread acceptance of the concept of multiple-use in both land and water management there has been relatively little investigation of the possible limits to multiple-use combinations. The compatibility of pairs of land uses are summarized by Clawson, Held, and Stoddard,[21] and of pairs of water uses by Ackerman and Löf.[22] These are based chiefly upon observation of experience in resource management, and tend to group three distinct types of limiting criteria in one classification—technological, economic, and social. For any pair of uses the degree of complementarity may be different for each of these three criteria and subject to wide variation over area.

A. *Theoretical Range of Choice*: A decision in resources management involves, theoretically, a choice among a large number of possible adjustments and uses which might be applied to the particular physical environment. The manager has the option of using the resource in any one of the ways in which such a resource has ever been used by man, and there is always the possibility that he may invent a new way of using it. Thus, a chernozem soil may conceivably be used to grow a large number of crops in farming systems in which the operating unit varies from a few acres to more than 1,000 acres and in which livestock may

21. Clawson, Held, Stoddard, Land for the Future 448 (1960).

22. Ackerman and Löf, Technology in American Water Development, Resources for the Future 89 (1959).

play no role or a dominant role. Many such variations are known to be practiced in chernozem areas. But, in addition, a farmer may devise a new type of use, for example, cultivating water fowl in poorly-drained phases of land.

The theoretical range of choice may be defined as that number of adjustments and uses that have been practiced in any similar environment, plus a possible innovation. This number may reach astronomical proportions for certain types of area as in the case of alluvial valleys in middle and low latitudes. Maass and Hufschmidt have pointed out the immense number of possible combinations of water use and control in a sample drainage area.[23] It becomes necessary to examine the adjustments and uses according to their major types and distributions, and this has been done by geographers in many observed situations.[24]

B. *Practical Range of Choice*: No manager ever has open to him in practice the full theoretical range of choice. He has some choices which he may quickly reject because they seem to him unwise. There always are others that are closed to him, however wise or unwise they might appear to him or to others upon careful investigation. Usually, these blocked choices seem to derive from one or both of two aspects of social guides in the manager's culture. One aspect is awareness, the other restraint.

Although a scientist may be aware of theoretical possibilities for extracting ore, the mine manager may be entirely ignorant of them. Or even if the manager has heard of a different method of ore treatment he may not be aware of its relevance to his situation. Thus, a miner may consider that a cyanide process for obtaining gold would not work with his tungsten ore although in another place the process has been successful. Lack of awareness of the possible choices is a product of the social environment and of the kind of communication system that it affords its members. Illiteracy; poor schools; paucity of books, libraries and journals; and lack of communication with other areas are some of the conditions effectively shutting a manager off from knowledge of ways that otherwise would be open to him. There is always a time lag in the diffusion of new techniques. Even where institutions of teaching and publication are well advanced, habits of perception may prevent certain situations or ideas from being recognized by the manager.

With or without awareness of all the possible choices, there are many social restraints which block uses in various situations. At one organizational extreme are the formal strictures of a political agency, as in the case of prohibition of opium culture. At the other extreme are the subtle but no less rigid restraints of social attitude and tradition. Dietary preferences, religious beliefs, tribal customs, social status systems, or personal values may prevent a manager from considering

23. Maass and Hufschmidt, Toward Better River System Planning, Resources Development: Frontiers in Research 1133 (1960).

24. For reference to the spread of geographic work see Hartshorne, Perspective on the Nature of Geography (1959), and Ginsburg, Natural Resources and Economic Development 47 Annals Ass'n Amer. Geog. 197 (1957).

any substantial departure from the use he currently is practicing. In between these extremes are innumerable shades and forms of restraint, many of which have been recognized in institutional economics. Social guides combine to limit in greater or less degree the choices that a manager perceives and can feel free to consider. The practical range of choice always is narrower than and often tremendously reduced from the theoretical range of choice. A manager may not be conscious of making a choice among many possible uses. He simply may feel that he must without question go on doing in one year what he did in the preceding year and what his father did before him. This is the most elementary form of choice—the reaffirmation of the past.

III. ELEMENTS IN DECISION MAKING

Given a practical range of choice that is open to the resource manager it remains to note the kinds of considerations that enter into the process of selecting a course of action. It will help to assume that a theoretical description of elements of that process for the most complex market society under governmental restraints is capable of being used to arrange those possible elements in other societies. This implies that an element of decision-making in non-market economies might be found in market economies, an assumption which has not been fully tested. If the possibly crucial elements in decision-making can be distinguished, the next step is to ask whether or not they are recognized, and, if recognized, to examine the quality and areal implications of the way in which they are handled. The questions then are: How does the manager deal with this aspect of decision-making? How does his appraisal compare with that made by others? In each case the description of the element in choice involves first identifying the resource manager's view and then assessing its weight in his decision.

To isolate such elements in decision-making is not to describe that process directly in all its social aspects; it merely describes possible elements in it and thereby lays the groundwork for determining peculiar combinations of elements at a given time and place. For example, the maximization of net gains—a standard economic formulation of decision-making—may be found to be completely absent in one area while in another it is dominant. And even where dominant it may be applied incorrectly.

It is suggested that resource managers whether they be owners or tenants, peasants or public agents, in arriving at a choice of use or uses to be made of a specified resource, evaluate some or all of the following elements:

1. The quantity and quality of the physical resource. This is expressed in resource estimates which may range from casual and highly biased perception to accurate scientific inventory or appraisal.

2. The present value of the gains and losses accruing from future use of the resource. This commonly is expressed in discount rates and benefit-cost ratios. It necessarily includes an estimate of future demand for the utility created by use as expressed in demand curves and projections.

3. The technological change which might affect future demand, future production, and compatible use combinations. This is expressed in projections of techniques for consumption and production.

4. The relation of any given use to other resource use in contiguous or functionally linked areas. This is expressed in regional plans or spatial linkage.

From these considerations emerges a choice among possible uses or multiple-uses. Other elements no doubt enter into the decisions, but these are taken in this preliminary statement as covering considerations in many situations studied.

A. *Rationality and Perception*: Such analysis need be neither conscious nor explicit. The manager may ignore it or may exercise it by assuming invariance. He may take a position ranging from intuitive acceptance to highly sophisticated computation, but a position which in many instances can be identified. These analyses neither need to be rational nor linked together in a rational manner. Their association may dramatically bespeak irrationality. It nevertheless identifies the character of analysis that has been in fact used in managing the resource.

Another phase of the manager's appraisal also is important. It is the relation of his appraisal to other appraisals made by presumably more objective methods. How does a farmer's estimate of the potentialities of his soils compare with the classification by a government soil scientist? How does a city council's estimate of the economic gains and losses from investment in a new water supply compare with the estimates of an econometrician? Perception of environment is a basic feature of resource management and may drastically limit the practical range of the choice. From this starting point through appraisal of possible uses, income streams, technological trends, and regional impacts, the comparison of the manager's appraisal with that of others helps identify distinctive and crucial aspects of decision-making.

An examination of the analysis followed for each element deepens understanding of the full decision that is made in the social setting and reveals the facts, perception, aims, and values upon which that decision is based. And it is such understanding, especially in its areal implications, that deserves cultivation. To examine these analytical problems in resources management does not necessarily require different sorts of data than in the more conventional resource approaches, but it does ask a somewhat different set of questions. Different, and possibly more rewarding answers, then may result.

According to this view, the interaction of population, environment, and technology takes place within a framework that may be considered to have three parts. The *theoretical range of choice* open to any resource manager is set by the physical environment at a given stage of technology. The *practical range of choice* is set by the culture and institutions which permit, prohibit, or discourage a given choice. The *actual* selection within those limits depends upon the way in which a manager analyzes the different elements of the decision, and it apparently does not involve continuous functions, but rather, discontinuous ones

which may be recognized as turning on sensitivity points. The process of decision might be stated in mathematical form, but for this preliminary report it will be sufficient to state it in tabular form.

IV. DECISIONS IN MANAGEMENT OF FLOOD PLAINS

A recent geographic study of urban occupance of flood plains in the United States[25] may be used to illustrate the approach. This is selected partly because some results are at hand, but also because they provide a situation in which one characteristic of the physical environment—floods—is readily measured and is subject to concrete predictable manipulation. Within a flood plain the combination of land and water resources may be relatively uniform back from the stream channel. The following illustrations assume that flood hazard in those situations is the chief variable in the resource base. This is an over-simplification, but will serve to suggest the complexity which might be expected where the resource is less uniform and the range of use greater.

A common approach to flood problems has been to ask what areas and activities are subject to flood damage, what is the character of flood occurrence, what kinds of protection have been provided, and what is the public investment and policy in flood control. These are all interesting and pertinent points, yet their elaboration from year to year has neither greatly advanced understanding of the complex decisions which have led to occupance of flood plains nor charted grounds upon which the consequence of changes in public policy affecting flood-plain use might be predicted.

If flood-plain use is approached in terms of methods of analysis followed by the resource managers the following questions are asked: How do managers of flood-plain land estimate the flood hazard? What is their estimate of the productivity of the flood plain in the light of frequency and magnitude of flooding? How are the gains and losses of various possible adjustments calculated? What attention is given to harmonizing flood adjustments and flood-plain uses with other resource uses? What account is taken of technological change in projecting future demand and adjustments? How is the solution for one area related to management of resources in contiguous or functionally linked areas? What social guides either restrain or encourage flood-plain use? Five situations will be described briefly.

A. *The Case of One Manager*: A relatively simple example is the manager of an isolated residential property subject to occasional flooding. He is well informed about the hazard, he knows what other home owners in similar situations have done about flood losses, and he is committed to maintaining his use for resi-

25. White, Calef, Hudson, Mayer, Sheaffer, Volk, Changes in Urban Occupance of Flood Plains in the United States (U. Chi., Dept. of Geography Research Paper No. 57, 1958).

dential purposes. What adjustments can he make to flood hazard in continuing his use of the site?

TABLE 1

Elements in Choice of Adjustment to Flood Hazard by One Home Owner in a Flood Plain
Single use: Residential

Theoretical range of adjustments	*Practical range of choice*	*Elements in choice*					*Actual choice*
		Estimate of hazard	*Techno-logical trends*	*Economic efficiency*	*Spatial linkage*	*Others*	
Bear the loss	o	−	+	−	+	.	R
Insurance	x	.	.	.	.	.	R
Land elevation	o	+	−	−	−	.	R
Structural change	o	+	−	+	+	.	R
Emergency action	o	+	−	+	+	.	A
Flood abatement	x	.	.	.	.	.	R
Flood protection	x	.	.	.	.	.	R
Public relief	o	+	+	+	+	.	A

x Blocked choice
o Open choice
+ Favorable to choice
− Unfavorable to choice
A Accepted
R Rejected

As shown in Table 1, there is a theoretical possibility that he could obtain insurance, but this is blocked by the general refusal of insurance companies to cover flood losses. He does not consider abatement or protection because he understands this would require work off his property. Land elevation, change in structural features, and preparation for emergency action would be possible adjustments, and his estimate of flood hazard would encourage some action along those lines. He is discouraged from undertaking any of these by the prevailing belief in his community that because the government is doing something about water control in the region, floods will be reduced in the future. Some rough calculations of loss to be prevented convince him that it would pay him to invest in structural changes in preparing for and carrying out emergency action, *i.e.* shifting his storage room and electrical appliance connections. By the same means he concludes land elevation would be too expensive and that it might, moreover, land him in a lawsuit with a neighbor whose drainage system would be interrupted. Although he thinks his losses may decline as engineering works improve, he thinks he cannot afford to bear the loss indefinitely. In his terms, any adjustment he might make except land elevation would not harm him through its effects upon the community. Public relief will be offered in time of disaster, and he gradually decides to rely partly upon such help and to prepare for emergency moves when the next flood does strike.

He has arrived at this position over a period of time without ever stating a formal decision, but the apparently pertinent considerations are summarized in Table 1. His rejection of structural change is to be traced to his sanguine feeling

about technological progress and his confidence that public relief will bail him out of a serious disaster.

Simpler cases might be described. The new home owner, of which there must be thousands in the United States, who is totally unaware of flood hazard and who unwittingly bears some of the loss and is a candidate for public relief would be shown as having only those two practical choices. Many resource managers in flood plains believe they have no other choice than to bear the loss.

B. *The Case of a Single-use Neighborhood*: If the same questions are asked about a neighborhood of residential property owners in which there is uniformity of attitude toward floods and the use of the flood plain, the kind of situation described in Table 2 might be encountered.

TABLE 2

Elements in Choice of Adjustment to Flood Hazard
by a Neighborhood of N Home Owners
Single use: Residential

		Elements in choice					
Theoretical range of adjustments	*Practical range of choice*	*Estimate of hazard*	*Techno-logical trends*	*Economic efficiency*	*Spatial linkage*	*Others*	*Actual choice*
Bear the loss	o	−	+	−	+	.	R
Insurance	x	.	.	.	.	.	R
Land evaluation	o	+	−	−	−	.	R
Structural change	x	.	.	.	.	.	R
Emergency action	x	.	.	.	.	.	R
Flood abatement	o	+	+	+	+	−	R
Flood protection	o	+	+	+	−	+	A
Public relief	o	+	+	+	+	.	A

Again, it is assumed that they are committed to continuing residential use, and in this case a zoning ordinance limits the choice of use. They are not, however, as well aware of the theoretical choices as the single owner described above. While they know of land elevation they reject it as being too expensive, probably soon outmoded, and likely to cause trouble with the community across the river. They do not consider insurance because it is unavailable. Structural change and emergency action are ignored because such adjustments are unknown. The managers are encouraged to count on public relief but they would prefer the greater security of either a Watershed Protection project or a small reservoir project. The former, from the standpoint of the community, would be desirable in all regards except that it would require extensive organization of landowners upstream and this "other" consideration seems insurmountable in a reasonable period of time. Therefore, they push for a construction project at federal expense.

C. *The Case of Choice for Vacant Property*: In the two preceding cases it was assumed that choice applied only to type of adjustment for a single use. The description becomes more complicated when a large vacant property in the hands of one manager is considered and three possible uses are canvassed. In this instance, as shown in Table 3, the manager considers some adjustments for residential, recreational, and commercial use.

TABLE 3

Elements in Choice of Adjustment to Flood Hazard and of Land Use by One Manager of Vacant Urban Property
Uses: Vacant; Recreational; Residential; or Commercial

		Elements in choice					
Theoretical range of adjustments and uses	*Practical range of choice*	*Estimate of resource*	*Techno-logical trends*	*Economic efficiency*	*Spatial linkage*	*Others*	*Actual choice*
Vacant	o	—	—	—	—	.	R
Residential							
Bear the loss	o	+	+	—	+	.	A
Insurance	x	.	.	.	.	.	R
Land elevation	o	—	—	—	—	.	R
Structural change	x	.	.	.	.	.	R
Emergency action	x	.	.	.	.	.	R
Flood abatement	x	.	.	.	.	.	R
Flood protection	o	—	—	—	—	.	A
Public relief	o	+	+	+	+	.	A
Recreational							
Bear the loss	o	+	+	—	+	.	R
Insurance	x	.	.	.	.	.	R
Land elevation	o	—	—	—	—	.	R
Structural change	x	.	.	.	.	.	R
Emergency action	x	.	.	.	.	.	R
Flood abatement	x	.	.	.	.	.	R
Flood protection	o	—	—	—	—	.	R
Public relief	o	+	+	—	—	.	R
Commercial							
Bear the loss	o	—	+	—	—	.	R
Insurance	o	+	—	+	+	.	A
Land elevation	o	+	—	+	—	.	A
Structural change	o	+	—	+	+	.	A
Emergency action	x	.	.	.	.	.	R
Flood abatement	x	.	.	.	.	.	R
Flood protection	o	+	—	—	—	.	R
Public relief	o	—	+	—	—	.	R

He decides to develop part of the land for residential purposes, allowing the new residents to bear whatever loss is not covered by public relief, and to develop the other part for commercial use. In the latter decision, however, he knows from a skillful architect that by a combination of land elevation, structural change, and

insurance available to large commercial users he can deal with all foreseeable losses, and he goes ahead with this without relying upon other adjustments.

D. *The Case of a Zoning Agency*: If a similar piece of property is within the jurisdiction of a zoning board it would be subject to a different kind of analysis as shown in Table 4.

TABLE 4

Elements in Choice of Adjustment to Flood Hazard and of Land Use by County Zoning Agency for Vacant Urban Property
Uses: Residential; Recreational; or Commercial

		Elements in choice					
Theoretical range of adjustments and uses	*Practical range of choice*	*Estimate of resource*	*Techno-logical trends*	*Economic efficiency*	*Spatial linkage*	*Others*	*Actual choice*
Residential							
Bear the loss	o	−	−	−	−	.	R
Insurance	x	.	.	.	.	.	R
Land elevation	o	+	+	+	−	.	R
Structural change	o	+	+	+	−	.	R
Emergency action	o	+	+	+	+	.	R
Flood abatement	o	+	+	+	+	−	R
Flood protection	o	+	+	+	−	−	R
Public relief	o	−	−	−	−	−	R
Recreational							
Bear the loss	o	+	+	+	+	.	A
Insurance	x	.	.	.	.	.	R
Land elevation	o	−	+	−	−	.	R
Structural change	o	+	+	−	+	.	R
Emergency action	o	+	+	+	+	.	A
Flood abatement	o	+	+	−	+	.	R
Flood protection	o	+	+	−	−	.	R
Public relief	o	+	+	+	+	.	A
Commercial							
Bear the loss	o	−	+	−	−	.	R
Insurance	x	.	.	.	.	.	R
Land elevation	o	+	+	+	−	.	R
Structural change	o	+	+	+	−	.	R
Emergency action	o	+	+	+	+	.	R
Flood abatement	o	+	+	+	+	−	R
Flood protection	o	+	+	+	−	−	R
Public relief	o	−	+	−	−	−	R

Here, the same range of adjustments and uses is considered as in Table 3, but insurance is excluded because a public agency cannot assume it to be available. The judgment is reached that land elevation and certain new structures would be deleterious because of effect upon channel efficiency, causing damage to other property. It also is concluded that occupance of the land for either residential or commercial purposes would lead to a situation where investment in flood

abatement or flood protection works under prevailing federal policies might later be found justified but that the community would not like to face the cost involved in contributions to the works and in relief during the intervening time before construction could be expected to begin. There is need for setting aside recreational open space in the growing community; the riverine situation has special amenities; and there is land elsewhere in the county equally well situated for residential and commercial purposes. Thus, the land is zoned for open recreational use.

E. *The Case of a Construction Agency*: The preceding cases have described a high degree of choice on the part of resource managers. These illuminate the possible variations but they should not be taken as representative of flood-plain situation. It is known, for example, that while some managers such as those in Pittsburgh's Golden Triangle make the kind of analysis shown in Table 3, there are many who apparently consider only public relief or public protection as an alternative to bearing the loss. This situation is reinforced by federal policy which has emphasized construction works.

TABLE 5

Elements in Choice of Adjustment to Flood Hazard by a Federal Engineering Agency
Use: Residential

		Elements in choice					
Theoretical range of adjustments and uses	*Practical range of choice*	*Estimate of resource*	*Techno-logical trends*	*Economic efficiency*	*Spatial linkage*	*Others*	*Actual choice*
Residential							
Bear the loss	x	.	.	.	.	.	R
Insurance	x	.	.	.	.	.	R
Land elevation	x	.	.	.	.	.	R
Structural change	x	.	.	.	.	.	R
Emergency action	x	.	.	.	.	.	R
Flood abatement	x	.	.	.	.	.	R
Flood protection	o	+	+	−	−	+	R
Public relief	x	.	.	.	.	.	R
Other use	x	.	.	.	.	.	R

The decision of a federal engineering agency in appraising the flood problem in a residential neighborhood of the type described in Table 2 is narrowly defined. The agency, as shown in Table 5, considers only whether protection works are justified or not according to federal policy. It finds that the hazard is serious and will not be reduced by technological changes upstream; and, as another consideration, it has the encouragement of a strong Congressman. It recognizes, nevertheless, that the economic efficiency is low and that the works might cause

distress elsewhere. The proposed construction project is rejected and no substitute is offered to the neighborhood.

V. IMPLICATIONS FOR POLICY

This tabular scheme, it must be reiterated, does not necessarily explain why the manager arrives at his final decision. It attempts to describe how he does so, and takes a necessary step toward arriving at an explanation of his behavior. It may have succeeded only in raising questions that are unanswerable for the present.[26] For example, under this scheme it may become apparent that the kind of perception which certain resource managers have of the flood hazard is related to their consideration of a wider range of adjustments, and it therefore appears that an extended program of public information about flood hazard through the publication of maps would alter management decisions by others. A further check of the effect of maps shows that the other managers do not respond to such information. Without an explanation for these different perceptions of flood hazard, it may be difficult to design information programs that are effective, and much of the effort expended on flood hazard maps may be lost.

However, when the questions stated earlier become the framework of investigation, understanding of problems of flood-plain occupance sometimes deepens through a more nearly precise description of crucial elements in management decisions. Accordingly, the capacity to predict probable effects of a given change in flood-plain management is strengthened.

A few sample findings may be cited. Attention to estimates of the flood hazard as one aspect of the resource leads to classification of flood-plain situations into those in which managerial perception of the flood hazard corresponds to the hydrologic realities and those in which it does not. This reveals in the United States, among other findings, an extraordinary unawareness of catastrophic hazards. Investigation of estimate methods also suggests characteristics of floods which limit the kinds of decisions which are made. For example, it becomes evident that while classification according to flood origins is not especially significant to managerial decision, the flood-to-peak slope of the hydrograph does set the limits within which certain classes of emergency adjustments, such as flood warning and flood proofing, can be made. A new, much more meaningful, classification of streams on that criterion then emerges.

Appraisal of methods of discounting present value of future gains and losses from various possible adjustments to the flood hazard reveals, first of all, major classes of adjustment that commonly are ignored. It later directs attention to the spatial linkages, such as the costs of stream-channel encroachment, which are given little or no weight. Appraisal of the methods of projecting demand for flood-plain land shows wide variation among the managers. Private mana-

26. Much of this is based upon papers to be published in 1961 by Berry, Burton, Kates, Roder, and Sheaffer in a research paper of the U. Chi. Dept. of Geography.

gers tend to overestimate. The federal agencies often follow a method out of line with the realities of change in land use in observed situations, and for convenience assume no increase in demand unless required to produce a favorable benefit-cost ratio. It then becomes possible to classify flood plains according to population growth characteristics, and to suggest relationships between such growth and changes in occupance as well as to point out the effects of the public demand estimates upon further occupance. Investigation of linkage between flood-plain use and uses in other areas suggests the existence of definite patterns of growth that may be triggered by developments off the plain. Considerations of relative location then demand attention.

In another vein, the preparation for a zoning agency of a description, such as that in Table 4, may promote an intelligent canvass of the place of public regulation of land use. Regulation of flood plains is not necessarily wise, and the justification for it needs to be checked against the public goals to be served in a specific situation.[27]

VI. SENSITIVITY POINTS AND SOCIAL PROCESS

In examining elements involved in decision-making in the field it may be found that there are characteristics of the area in each case which establish constraints upon the management of a resource no less effectively than the institutional constraints. For example, in the urban occupance of flood plains man is not likely to go into areas which are flooded as frequently as once every year or once every two years. Where the frequency is as great as once in every three to twenty-five years the managers are likely to occupy the flood plain but with some consideration of alternative adjustments. Where the frequency is less than once in twenty-five years there is a pronounced tendency to assume that there will never be another flood, and it makes little difference whether floods come once in twenty-five or once in 200 years. This relationship between flood frequency and estimates of flood hazard might be graphed for selected areas. In some situations it is clear that the two-year and twenty-five year frequencies are inflexion points on the curve, and that in the management of flood-plain properties they are likely to be critical. In trying to provide managers with needed data on the flood hazard these may then be taken as sensitivity points to identify and show on maps.

Another example from flood-plain occupance is the relationship between the feasibility of emergency adjustments and the flood-to-peak interval. As already suggested, the time periods in which it is practicable to make different forms of emergency adjustment set sensitivity points. In charting the areas in a basin in which emergency adjustments would be feasible it becomes important to map these points.

27. Dunham, Flood Control Via the Police Power, 107 U. Pa. L. Rev. 1098 (1959).

For each one of the elements of analysis in a given management situation it is, then, possible to think of a curve of relationship between the feasibility of a type of adjustment and a production factor. On the curve there may be one or more sensitivity points that are significant in the management decision. These identify critical items to map in seeking differences over area.

A. *The Test of Location*: To expand this description of choice to the situation in a larger area where many managers are involved is difficult but not impossible. It must be recognized that the aggregate decisions are not the simple algebraic sums of all the factors entering into the system of equations; that is, if the economic efficiency for one use is uniformly higher than for any other the aggregated choices will not necessarily favor that use. In each case, and possibly for somewhat different reasons in each case, the actual choice may be against the economically efficient use. The grouped decisions for an area are therefore the aggregation of the individual decisions and not the summation of the various factors in each.

This is an important distinction because it is common in discussion of resources use to make normative judgments, to say that where soils are low in certain nutrient values they will generally be used in a particular way. It might be expected that land values for a given use would vary with the severity of flood hazard. In some cases these statements of an average condition may hold as a description of resource use over a large area. In other cases they may have little relevance, such as where a soil type may be favorable for grain farming, but where grain is not raised in the area because of institutional or other blocks, or where land values do not reflect flood hazard.

Study of areal differentiation in use patterns may suggest sensitivity points in management. It also may present anomalies, and in either case the geographic analysis of use patterns goes hand in hand with analysis of decision-making.

B. *Social Process*: Descriptive analysis of this character does not imply any single concept of culture, social system, or social process. The validity of such concepts may be tested in part by the descriptions, and certain of the concepts may illuminate understanding of resource management decisions, but there is no necessary link. Thus, the way in which a flood hazard is perceived may be found to be closely related to cultural conditions in some societies. The awareness of possible choices such as structural change or flood protection may be shown to be a function of the social status of the resource manager. An examination of numerous flood-plain situations may suggest a sequence of occupance—such as, initial avoidance of flood hazard, later invasion as settlement continues, and final decision to protect the exposed users—that can be hypothesized as having general application. The responsiveness of a community to a reliable flood warning may be related to its social mobility and organization. All of these relationships have been examined recently in flood-plain studies.

VII. CHOICE OF USE IN PUBLIC FORESTS AND WATER PROJECTS

Against the background of this framework for examining resource management decisions, the multiple-use declarations of public forest and water programs now may be recalled. One striking aspect of both the forest and water declarations is that they are based upon only meager knowledge of the decisions currently made by resource managers in three fields. While the Multiple Purpose Forest Act is, in effect, a formalization of policies prevailing over the years in Forest Service practice, it presumes multiple-use to be desirable as a matter of public policy, and also assumes that wise choice can be made among the alternatives. The evidence from detailed analysis of forest management still is slim, and the methods of comparing choices are rudimentary. In the absence of precise guides from the Act itself as to ways of estimating the optimal combination of uses from a national standpoint, there is none of that routine or prescribed study which might provoke undue local irritation.

Similarly, studies looking to selection of economically justified combinations of water uses in new federal projects often spring from hortatory instructions rather than assessment of experience with water use. The conditions in which irrigators apply different amounts of water to their fields, the demand curve for industrial water, and the way in which flood-plain dwellers perceive the flood hazard are examples of gaps in knowledge as to present choices.

To expect responsible public choice without the benefit of such knowledge is to expect that policies and programs will be adopted without full appraisal of their consequences. Yet, it is wholly unrealistic to expect that forest supervisors will defer a judgment as to grazing-lumbering-recreation combinations while the necessary studies are being made, or that authorization of an irrigation project will await understanding of prevailing practices of water application in the benefiting area. Administrative action will not mark time while more studies are made. Moreover, it should be recognized that there can be heavy administrative resistance to any canvass of choices which lies beyond the prescribed authority of a public agency; the Corps of Engineers has not been quick to consider flood proofing as an alternative, however attractive, to the traditional engineering works; and the Soil Conservation Service has not taken wide initiative in appraising means of preventing those encroachments upon flood plains which can be protected by upstream measures. Agency commitments tend to strengthen rather than remove the obstacle to choice.

A second interesting aspect of forest and water multiple-use aims in the light of this analysis is the critical part played by spatial size and organization in shaping the expression of these aims on the ground. Although both the forest and water policies are stated in terms of national goals, their application vacillates from a primarily local view to a primarily national view and necessarily takes account of intermediate regional views. The variation in assessment of resources and possible uses which is displayed so clearly in the decisions of individuals,

communities, and national agencies in managing flood plains is even more apparent in the forest and water programs. Multiple-use may apply to an acre, a farm, a forest stand, or an entire national forest unit. It may be planned for a single dam, a small watershed, or an entire drainage basin; and, depending upon the size, number, and organization of establishments involved, the decision-making process will vary radically.

A third aspect is the self-fulfilling prophecy of some assumptions built into public choice. If it is assumed that irrigation or industrial water users will use water in inefficient quantities in terms of both physical and economic criteria, there will be a tendency to shape policy to provide supplies to care for the increasingly heavy withdrawals. Encouragement then is given to the users to continue their present practices. If the Corps of Engineers assumes that human invasion of flood plains will continue at a rapid rate and that it must maintain a construction program to protect the new damage centers, there is a strong probability that the program will indeed be needed. Only as the full range of possible choice is considered can there be clear recognition of the effects of assuming certain adjustments and uses.

In another paper I have tried to point out the importance to public policy in resource management of widening the range of choice among programs submitted for public action.[28] This requires the administrative machinery to make choices, and it can proceed effectively only insofar as there are reasonably handy tools for assessing the different choices in terms of their probable effects. One of the necessary tools is the method of analysis by which the nature of decision-making can be recognized. The method described here is crude, with a good many weaknesses, some of which have been noted. But it offers a way of examining the choice of resource use in a framework that takes account of the physical range of choice, the practical limits to choice, and the economic, technological, and spatial considerations entering into actual decisions. As the pressure for multiple-use becomes more intense and as the assessment of economic efficiency is refined, the need increases to understand management decisions and their consequences in such a framework.

28. Perspectives on Conservation 205 (Jarrett ed. 1958).