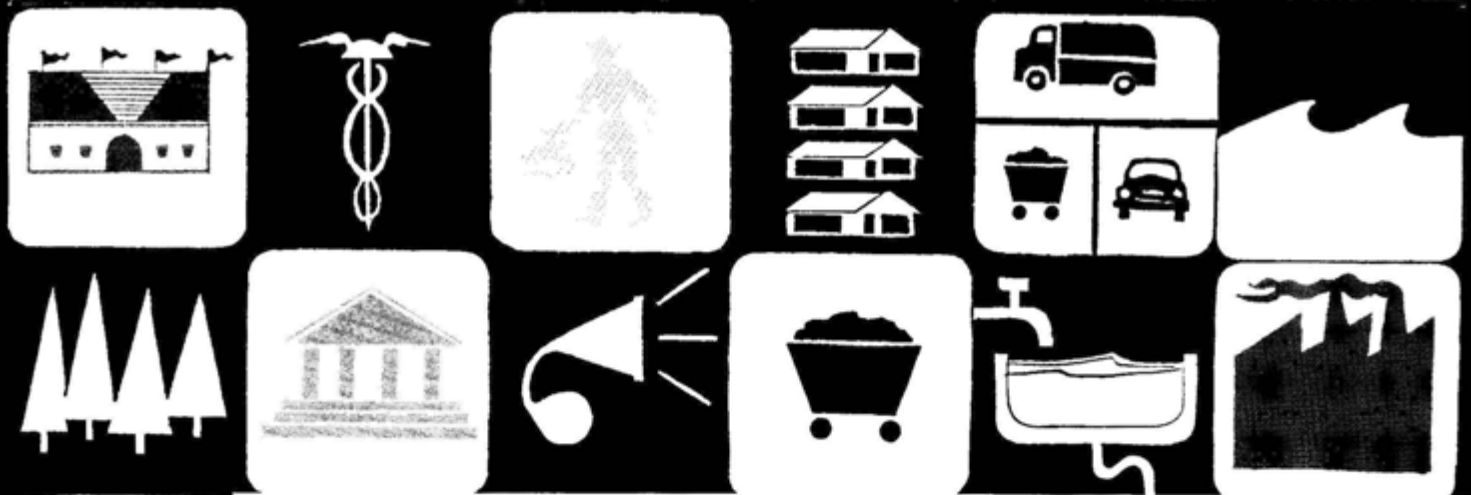
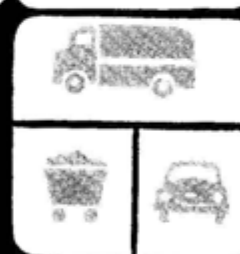




The PINCHOT INSTITUTE SYSTEM for ENVIRONMENTAL FORESTRY STUDIES



USDA FOREST SERVICE GENERAL TECHNICAL REPORT NE-2
1973

NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
WARREN T. DOOLITTLE, DIRECTOR



“Environment is not an abstract concern, or simply a matter of aesthetics, or of personal taste—although it can and should involve all of these as well. Man is shaped to a great extent by his surroundings. Our physical nature, our mental health, our culture and institutions, our opportunities for challenge and fulfillment, our very survival—all of these are directly related to and affected by the environment in which we live. They depend upon the continued healthy functioning of the natural systems of the Earth.”

RICHARD M. NIXON
August 1970

The PINCHOT INSTITUTE SYSTEM for ENVIRONMENTAL FORESTRY STUDIES

**by
The Pinchot Institute**

ABSTRACT

THIS PAPER describes a prototype system for research planning and administration to meet man's needs for forest vegetation in and around metropolitan areas. The system's components involve social needs or services, technological developments, environmental effects, and the locales where the services, developments, and environmental effects occur. The system is organized from three different perspectives—a social-need viewpoint, a supply-response viewpoint, and an environmental-effect viewpoint. A series of diagrams are presented that show, for each of the three viewpoints, how to formulate and evaluate problems suggested by combinations of various components in the system. Problems that are relevant to the system are those that can be solved by one or more of the following kinds of ecological manipulation procedures of natural forest stands throughout Megalopolis: change or maintain species composition, alter or preserve the density, improve or maintain productivity of an area, and rearrange or hold constant spacial patterns. Examples are provided on how the system can be applied, and various suggestions are made on how to improve it.

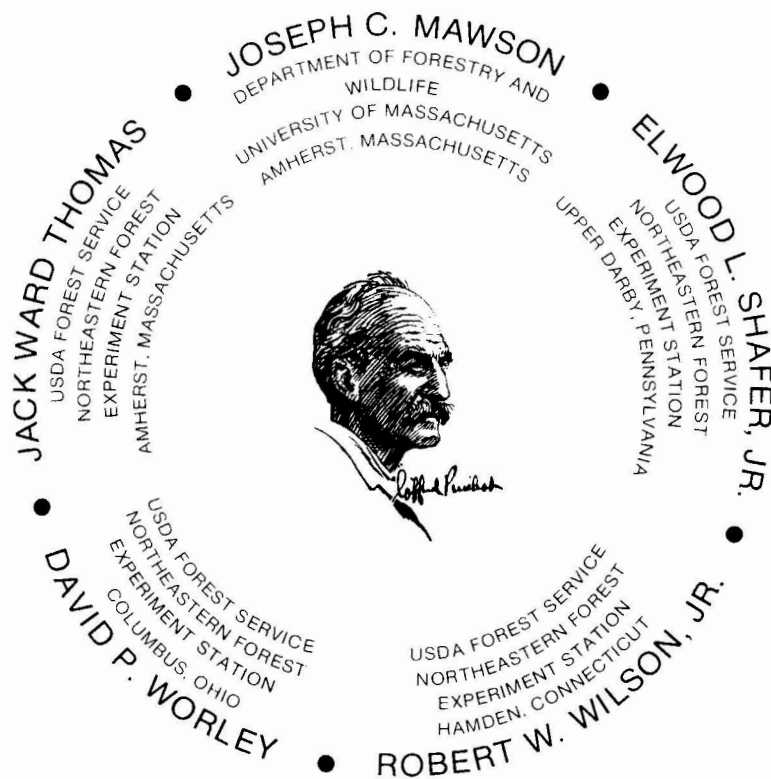
MANUSCRIPT SUBMITTED FOR PUBLICATION 8 AUGUST 1972.

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FOREWORD

THE RESEARCH-PROGRAM development and evaluation system described in this report was developed by an interdisciplinary team of the Pinchot Institute for Environmental Forestry Studies. The members feel that environmental research problems are best attacked by a team effort and that such an effort will be increasingly necessary in research efforts dealing with the interaction of man and his environment. This report is a fruition of that team effort. We believe that our prototype system for research planning and administration can be used, following appropriate modifications, by other disciplines and other government and private institutions in the conduct and administration of almost any type of research dealing with man-resource environmental problems.





A CRISIS

LIKE the Four Horsemen of the Apocalypse—harbingers of war, pestilence, famine, and death—four great threats today confront the ecology of the densely populated Megalopolis of the Northeast: water pollution, air pollution, soil erosion, and destruction of flora-fauna relationships.

In responding to this environmental crisis throughout Megalopolis, the most significant challenges to science are:

1. To establish a systematic research strategy for solving the relevant problems.
2. To set associated research priorities to organize scarce research resources.
3. To proceed, as quickly as possible, with the required research.

To do this, an overall systematic approach is needed that is related to social needs, that considers social controls as devices to achieve these needs, and that stabilizes or improves natural ecosystems required to enhance the social wellbeing of man.

Such a system has been developed by the Pinchot Institute.

THE PINCHOT INSTITUTE

The Pinchot Institute for Environmental Forestry Studies, an interdisciplinary research division of the U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, was created in 1970 to help improve—through environmental forestry research—human environments in the densely populated areas of the Northeast.

Environmental forestry involves those aspects of resource management dealing with man's needs for, and association with, the tangible and intangible values of forest vegetation in and around metropolitan areas. Such forested vegetation involves a wide range of forested conditions—ranging from city park environments to green belts and woodlands in the rural areas that intersperse the huge, sprawling, urban complexes throughout Megalopolis.

Where this forest vegetation exists, it modifies and improves living conditions, furnishes sites for recreation, protects and maintains water supplies, provides sanctuary for wildlife, screens industrial and highway developments, abates noise, reduces temperature, filters dust,

fumes, and other atmospheric impurities, and enhances the setting for aesthetic enjoyment.

The concept of *environmental forestry*, like that of *economics*, cuts across the full fabric of our national life on a broad range of resource-allocation decisions involving such diversified social services and needs as transportation, energy production, housing, employment, health and welfare, education, recreation, and technological development.

The Pinchot Institute involves a coordinated effort of university and Forest Service scientists working together to enhance the social wellbeing of man through the proper management of forest-resource values and effects in and around densely populated areas. The charter of the Institute's Consortium for Environmental Forestry Research describes the organizational procedures for accomplishing a coordinated forest Service-university research effort (appendix I). The Institute's objective is to provide information for megalopolitan decision-makers to help them maintain a proper ecological balance between urban man and his surrounding forest environments.

A STRATEGY

Establishing and administering a comprehensive environmental-research program such as that of the Pinchot Institute might be compared to playing three-dimensional chess. The easiest move is to develop individual research studies within a general problem area. This approach, which is common in environmental research, is like knowing no more about the game than one move that an individual chessman can make.

Deciding on how several research studies should be grouped to provide a satisfactory solution to any one overall general problem area of megalopolitan man parallels the chess player's need to understand how a series of moves on the board complement one another and how one move may affect other moves.

Understanding how groups of studies in each of several research-problem areas fit into a comprehensive research program is similar to the chess player's need to develop a strategy

that allows him to play the game in several dimensions at the same time.

And finally, insuring that the emphasis of a research program is relevant to the total social needs and technological developments of society parallels a chess player's need to know not only how his own, but also how the past, present, and future moves of other players in the game affect the patterns of play.

Our thesis is that, in environmental forestry research, too much attention has been devoted to planning and carrying out the details of individual research studies or groups of studies before adequate effort has been expended in understanding how such studies fit into an overall research program, and how these same studies are oriented to social needs and technological developments.

As environmental scientists, we have been playing in a kind of three-dimensional chess game, but we usually have concentrated our

efforts on only one dimension of the playing surface. In a sense, we have identified the capabilities of a few chess pieces and have developed a few moves on a chessboard that resembles the covers of this publication. However, the odds of winning the total game with such a strategy are extremely small. We believe that the odds of winning—meeting the real needs of decision-makers—can be increased by changing our strategy to one that calls for recognizing the interconnectedness of the problems, the ramifications of the solutions, and the need to prescribe comprehensive research approaches.

Our purpose here is to describe a strategy, or system, for either defining research problem areas for investigation, or for evaluating the effects of social services and technologies on natural forest-resource ecosystems in light of

the overall objectives of the Pinchot Institute.

This is a first-generation system, like a first-generation computer system containing vacuum tubes that could not handle overloads. It has in it a series of information vacuums that we have purposely passed through in tracing the entire flow of the system. At the same time, we recognize that these information vacuums require considerable research and improvement to define important details and interrelationships within the system.

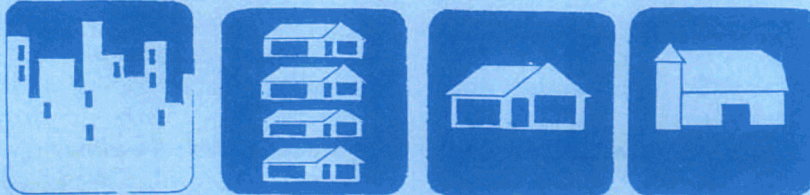
In much the same way that research on transistors and microminiaturization was required to advance computer technology to second- and third-generation systems, additional research is needed on the Pinchot Institute research system to make it more compatible with the present and future needs of metropolitan planners and managers.



SERVICES



LOCALES



DEVELOPMENTS



EFFECTS



THE SYSTEM

The proposed system for Pinchot Institute research deals with the man-dominated section of a forest environment ecosystem. The system is based on the following assumptions:

All changes or status quo conditions in an environmental forestry system can and will be evaluated in terms of services (or needs) required by man. These services are provided in a particular locale through the establishment of technological developments that eliminate or produce certain environmental effects (table 1).

Thus the primary components of the system are service, locale, development, and environmental effect. (See appendix II for definitions.)

The key elements listed for each component in the system (table 1) are neither mutually exclusive nor exhaustive of all possibilities, but they serve both to show the scope of the system and to focus on the important elements in each component.

At the outset, it is well to recognize that the system is people-centered and subject to criticism from a purely ecological viewpoint. Any research framework such as this, which deals with environmental problems in the megalopolitan Northeast, could not be otherwise. This intensely human-influenced environment will be a product of man—for either good or ill.

Table 1.—Components of the system for Pinchot Institute research

SERVICES required by man	LOCALES where the services are provided	Technological DEVELOPMENTS used to provide the services	Environmental EFFECTS
<i>Physical infrastructure:</i>			
1. Water supply & waste disposal	1. Urban	1. Heavy industry	1. Air quality
2. Energy provision	2. Suburban	2. Light industry	2. Water
3. Transportation	3. Exurban	3. Power	3. Soil
4. Housing	4. Rural	4. Residences	4. Temperature and humidity
5. Flood control		5. Transportation	5. Noise
6. Recreational structures		6. Cultural and institutional structures	6. Flora & fauna
<i>Institutional infrastructure:</i>			
7. Education		7. Forestry	
8. Employment		8. Agriculture	
9. Health & welfare		9. Mining	
10. Recreational activity			

RESEARCH PACKAGING AND PRIORITY ASSIGNMENTS

The key elements (table 1) were arranged into all possible four-way combinations to contain one key element per component. For example, going from left to right in table 1, the first combination would be:

Service	Locale	Development	Effect
Water supply	Urban	Heavy industry	Air quality

In terms of the numbers that identify these items, this would be designated as a 1-1-1-1 package.

In examining any four-item possibility, we intuitively retained only those packages in which one or more research problems suggested by a package could be solved by one or more of the following four kinds of ecological manipulation procedures:

1. Change or maintain species *composition* of vegetation. Example: The health and welfare (service 9) of youth in urban (locale 2) residences or ghettos (development 4) can be improved in summer by exposing them to maintained *compositions* of water and flora and fauna (environmental effects 2 and 6) in forests near cities.
2. Alter or preserve the *density* of vegetation. Example: The construction of a highway (development 5) in urban areas (locale 1) to provide transportation (service 3) produces noise and air pollution (environmental effects 1 and 5) that can be significantly abated by altering the *density* of vegetation near the highway.
3. Improve or maintain the *productivity* of an area. Example: Disposal of wastes (service 1) from residential areas (development 4) in urban rivers (locale 1) pollutes water quality (environmental effect 2). The problem can be alleviated by transporting treated wastes to nearby forest environments and spraying the affluent on the soil, which in turn filters out the nutrients and improves the *productivity* of the forest so that it can continue to act as a natural filtering agent to purify waste water.

4. Rearrange or hold constant *spacial patterns* of vegetation. Example: *Spacial patterns* of vegetation can be arranged so as to enhance the aesthetic quality of flora and fauna (environmental effect 6) at cultural and institutional structures (development 6) designed for recreational activities (service 10) in urban situations (locale 1).

The four constraints just listed relate a given research package (four-way combination of items in table 1) to man-forest interactions. The four-way packages generated specify man's role in these interactions. We incorporated the forest-related aspect by assigning a forestry-related solution constraint to any given package. In this way we filtered from all total possible packages only those packages in which forest-related variables may help solve problems of megalopolitan man.

This procedure for matching environmental forestry-research solutions to four-way combinations of services, locales, developments, and effects corresponds to the way a computer weeds out all the wrong answers until only the right answers are left. The magnitude of such weeding operations in this case dealt with taking the initial 2,160 possible four-way combinations of items and finally accepting only 321 that were meaningful in terms of Pinchot Institute objectives and constraints.

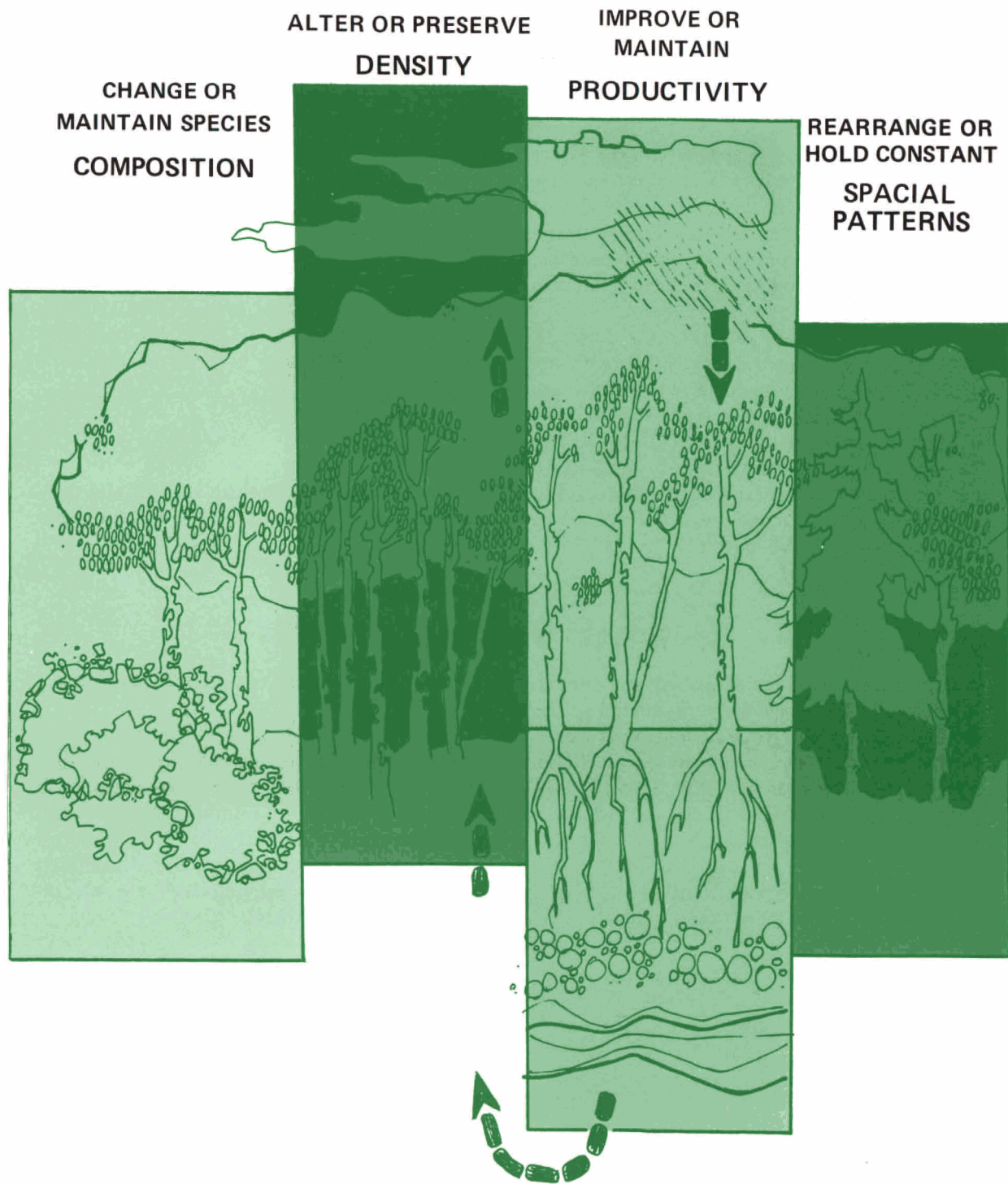
Each of these 321 packages was then assigned either a high or low priority rating, depending on the social-needs urgency for research in that particular package and the research.

To be rated high priority, a package had to meet two criteria:

1. There was an urgent social need for research within the package problem area.
2. There seemed to be a reasonable probability of success for associated research needs.

A low priority was given if a package met only one or none of these two criteria but still was a feasible area for research.

It should be recognized that the decisions made in the weeding and priority assignment were subject to the biases of the multidisciplinary-



any team involved. Therefore the packages that were eliminated are not necessarily meaningless, and any user of this system should be prepared to redirect any package that can be rationally proved viable for consideration. However, we believe that it would be rare to find such items in a search of both high- and low-priority items. In fact, low-priority items were retained in the system as a fail-safe insurance against elimination of viable research packages that may be explored in further refinements of the systems.

The procedure for selecting the final 321 packages was conducted partly by hand and partly by programming decision rules in a computer. The output at this stage was a list or catalog of problem packages (table 2). In a computer output display, though we can trace the packages through the entire matrix, it is difficult to see quickly the relationships among large segments of the matrix.

Table 2.—Partial list of acceptable research packages from computer output

Services	Locale	Development	Effect
HEALTH	URBAN	HEAVY	AIR
WATER	URBAN	HEAVY	SOIL
WATER	URBAN	HEAVY	NOISE
RECR	URBAN	HEAVY	NOISE
HEALTH	URBAN	POWER	AIR
ENERGY	URBAN	POWER	NOISE
RECR	URBAN	POWER	NOISE
HOUSING	URBAN	RESID	AIR
HOUSING	URBAN	RESID	NOISE
RECR	URBAN	RESID	NOISE
HOUSING	URBAN	RESID	FLORA
RECR	URBAN	RESID	FLORA
HEALTH	URBAN	RESID	FLORA
RECR	URBAN	RESID	FLORA
HOUSING	URBAN	TRANS	AIR

Our next step was to develop a display system that would enable us to use this information easily.

THREE VIEWPOINTS

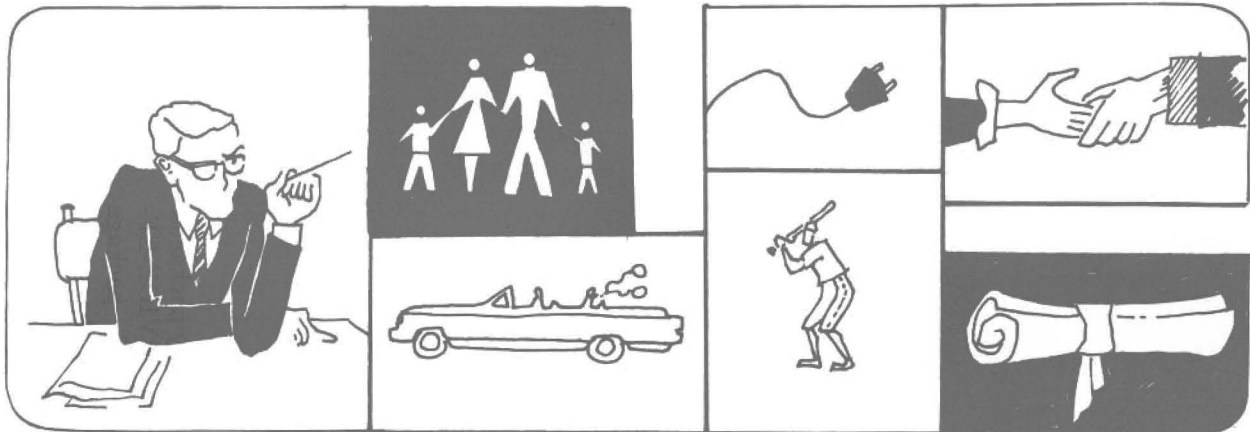
The system we have described was cumbersome to use. It needed to be organized so that complex research problems could be evaluated comprehensively and examined from different viewpoints. Therefore we arranged the 321 packages in three different ways to reflect the following three viewpoints:

1. A social-need viewpoint
2. A supply-response viewpoint

3. An environmental-effect viewpoint

These three perspectives of the system contain exactly the same research packages, both in makeup and in total number, but the packages are grouped differently for each viewpoint. From here on, it is not the individual packages that are important, but how they are interrelated and conceptualized.

SOCIAL — NEEDS VIEWPOINT



First, we can view the system from the standpoint of the policy-maker, decision-maker, or administrator whose primary responsibility is to provide services for urban man's needs. Here our major concern is policy formulation and decision-making about man-environment interactions. Indications of social needs within one or more of the services listed (table 1) include such elements as:

- Land values
- Tax structures
- Access patterns
- Supply and demand trends
- Ownership patterns
- Labor or professional union policies
- Ethnic and cultural values
- Congressional attitude

- Past legislation (federal, state, local)
- Interstate regulations
- Regional compacts
- Public opinions and attitudes
- Local ordinances
- Institutional objectives
- Past judicial precedences
- Pending law suits
- Pressure-group actions

By keying first on the services column (table 1), the system can be segmented as shown in figures 1 to 9. Ten services are listed in table 1, but transportation was not included for this particular viewpoint situation.

When the system is portrayed in this manner, the flow through the system can be coded as:

SERVICES ► EFFECTS ► DEVELOPMENTS ► LOCALES

For each social service in figures 1 to 9 the relevant relationships are shown among the service, environmental effect, development,

and locale components of the system where natural vegetation management may ameliorate related adverse environmental effects.

**THE SYSTEM FROM A
SOCIAL-NEED VIEWPOINT**

A given social service appears in the center of each figure. Interrelated environmental effects, technological developments, and locale packages are flow-charted outward from the center by relevant groupings.

Locales shown on the outer rim of each figure are coded as follows:

1. Urban
2. Suburban
3. Exurban
4. Rural

An asterisk identifies high-priority packages. For example, in figure 1 the SERVICE-EFFECT-DEVELOPMENT-LOCALE package labeled 1-2-7-3 is a high-priority package.

ARRANGEMENT OF THE SYSTEM FROM A SOCIAL NEEDS VIEWPOINT

SERVICES REQUIRED BY MAN	ENVIRONMENTAL EFFECTS	TECHNOLOGICAL DEVELOPMENTS USED TO PROVIDE THE SERVICES	LOCALES WHERE THE SERVICES ARE PROVIDED
PHYSICAL INFRA-STRUCTURE 1. WATER SUPPLY & WASTE DISPOSAL 2. ENERGY PROVISION 3. TRANSPORTATION 4. HOUSING 5. FLOOD CONTROL 6. RECREATIONAL STRUCTURES INSTITUTIONAL INFRA-STRUCTURE 7. EDUCATION 8. EMPLOYMENT 9. HEALTH & WELFARE 10. RECREATIONAL ACTIVITY	1. AIR QUALITY 2. WATER 3. SOIL 4. TEMPERATURE AND HUMIDITY 5. NOISE 6. FLORA & FAUNA	1. HEAVY INDUSTRY 2. LIGHT INDUSTRY 3. POWER 4. RESIDENCES 5. TRANSPORTATION 6. CULTURAL AND INSTITUTIONAL STRUCTURES 7. FORESTRY 8. AGRICULTURE 9. MINING	1. URBAN 2. SUBURBAN 3. EXURBAN 4. RURAL

FIGURE 1

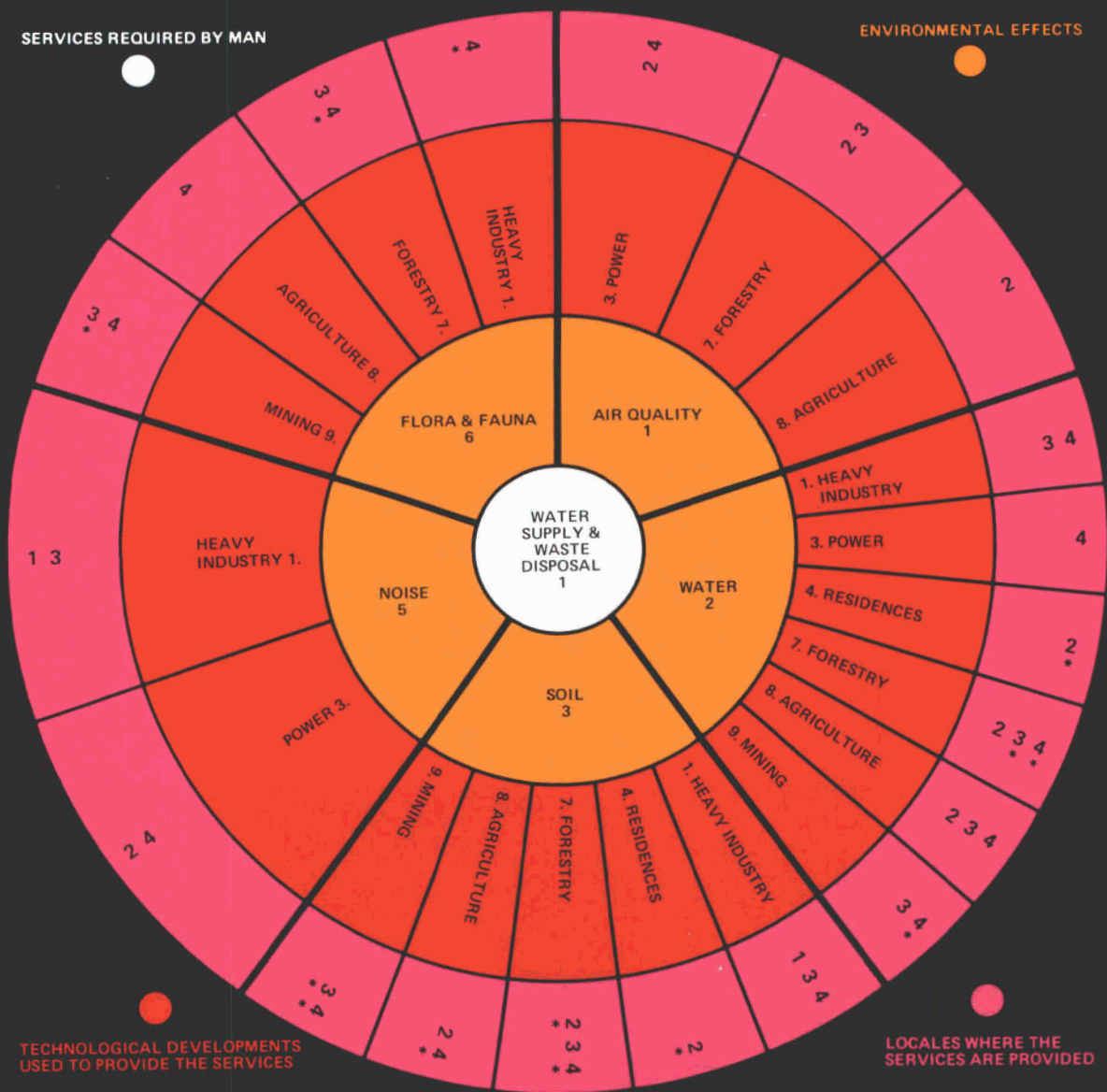


FIGURE 2

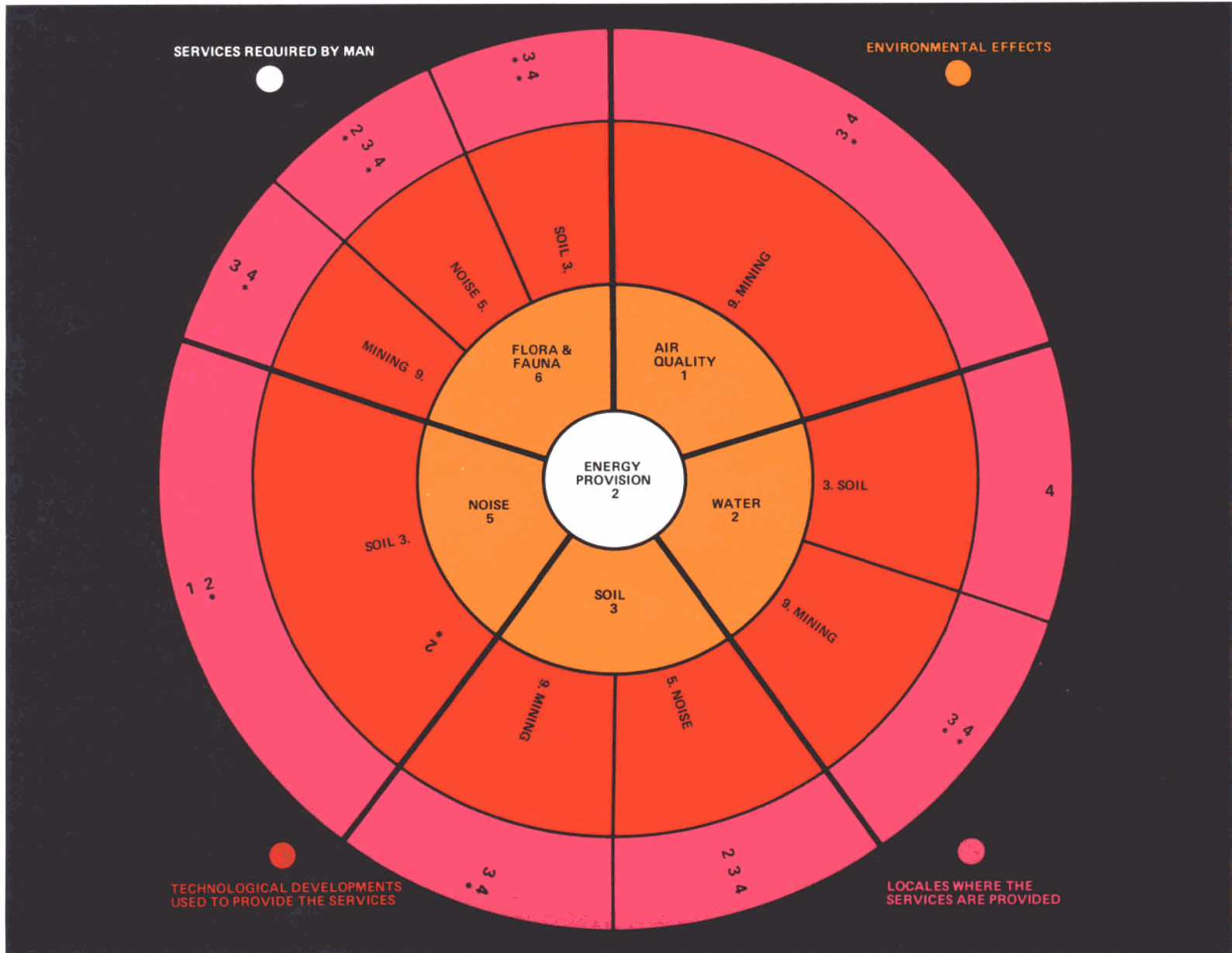


FIGURE 3

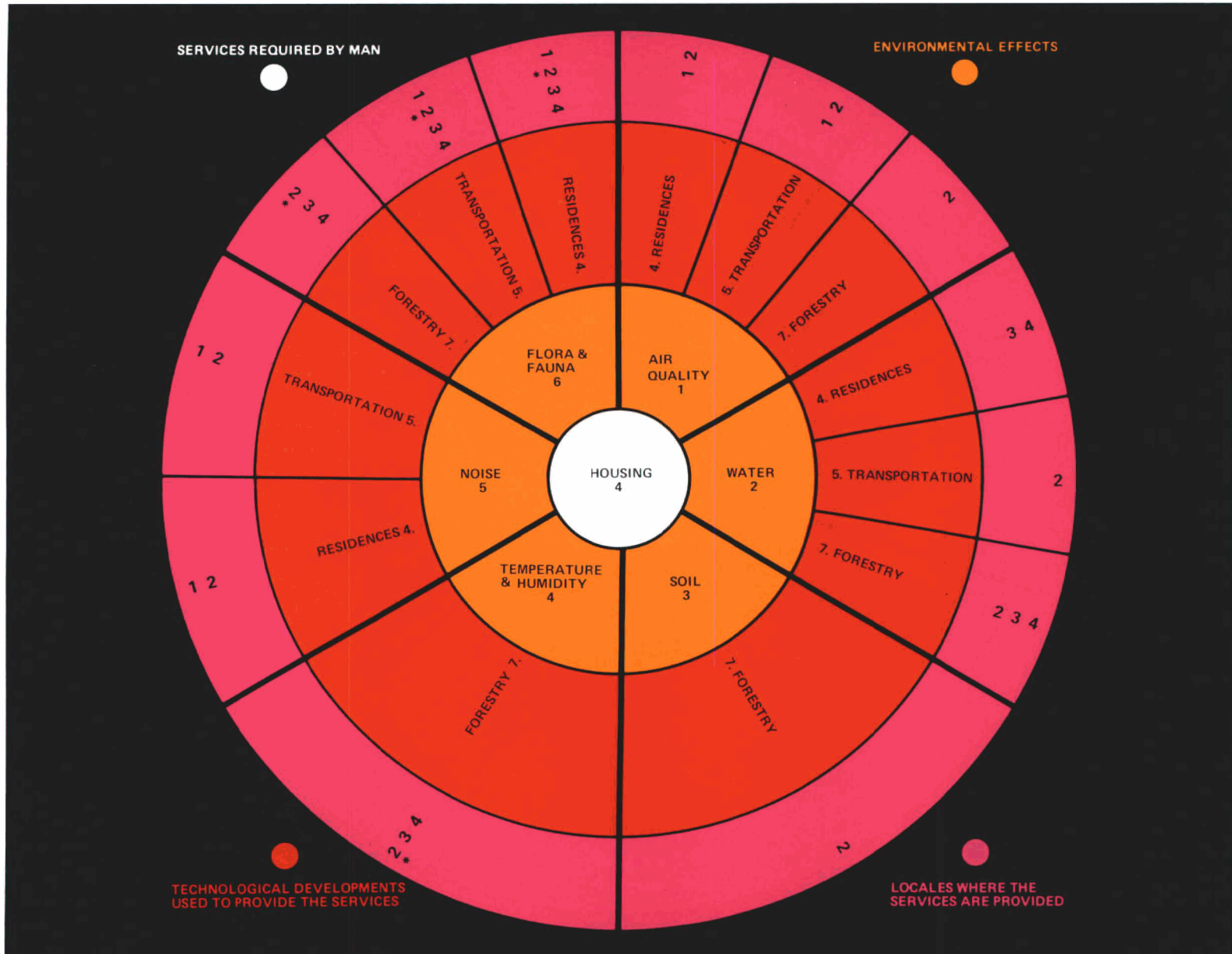


FIGURE 4

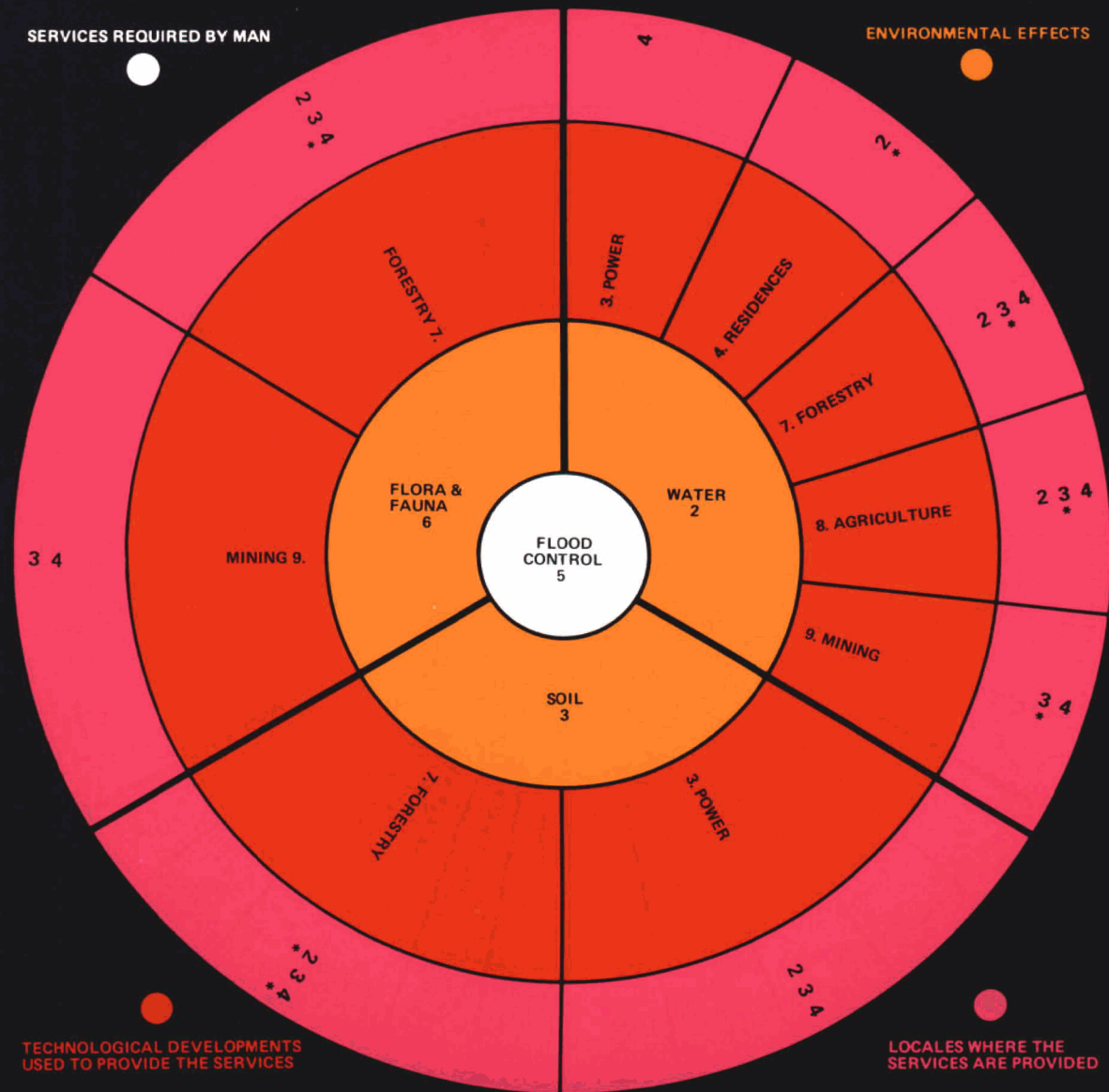


FIGURE 5

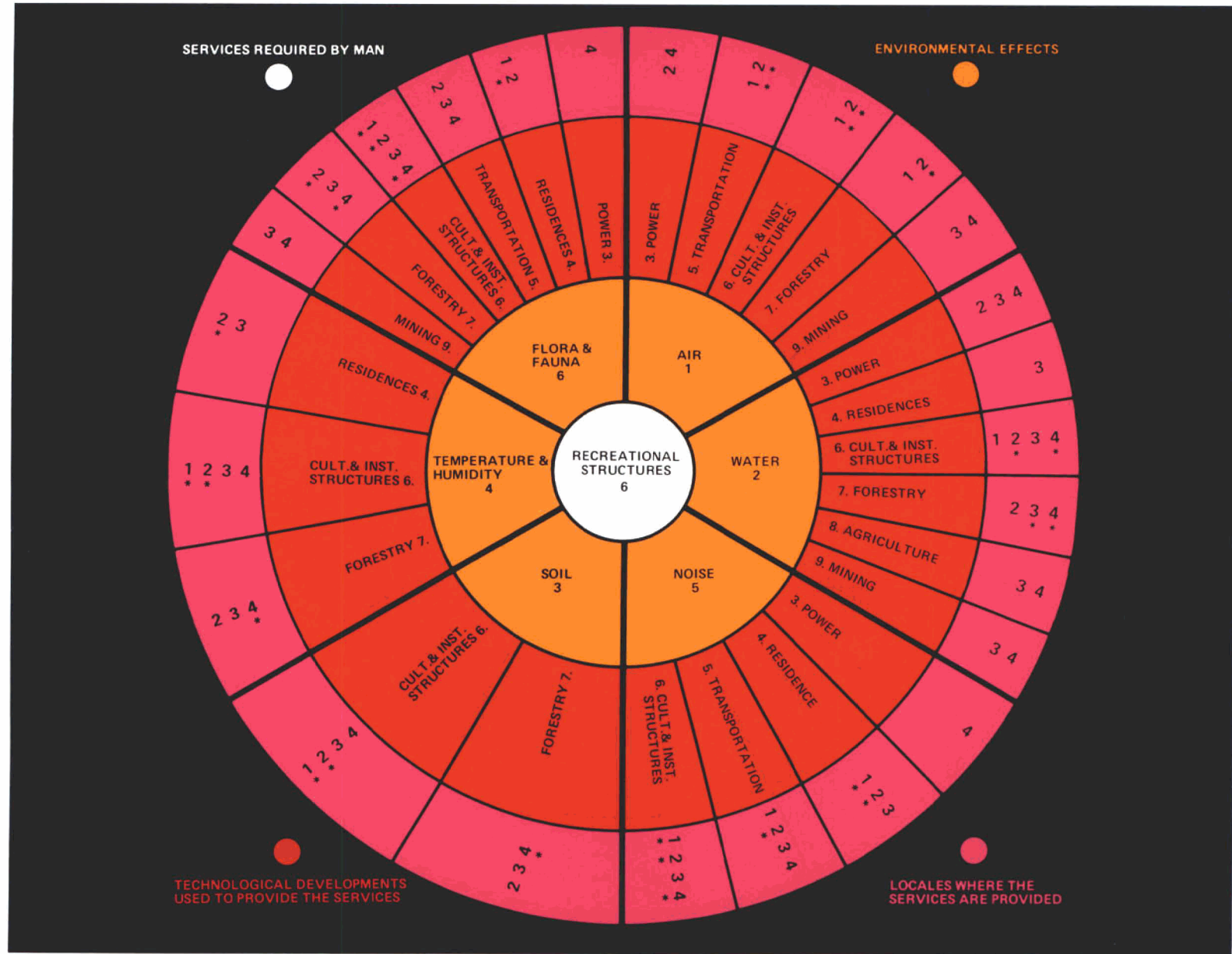


FIGURE 6

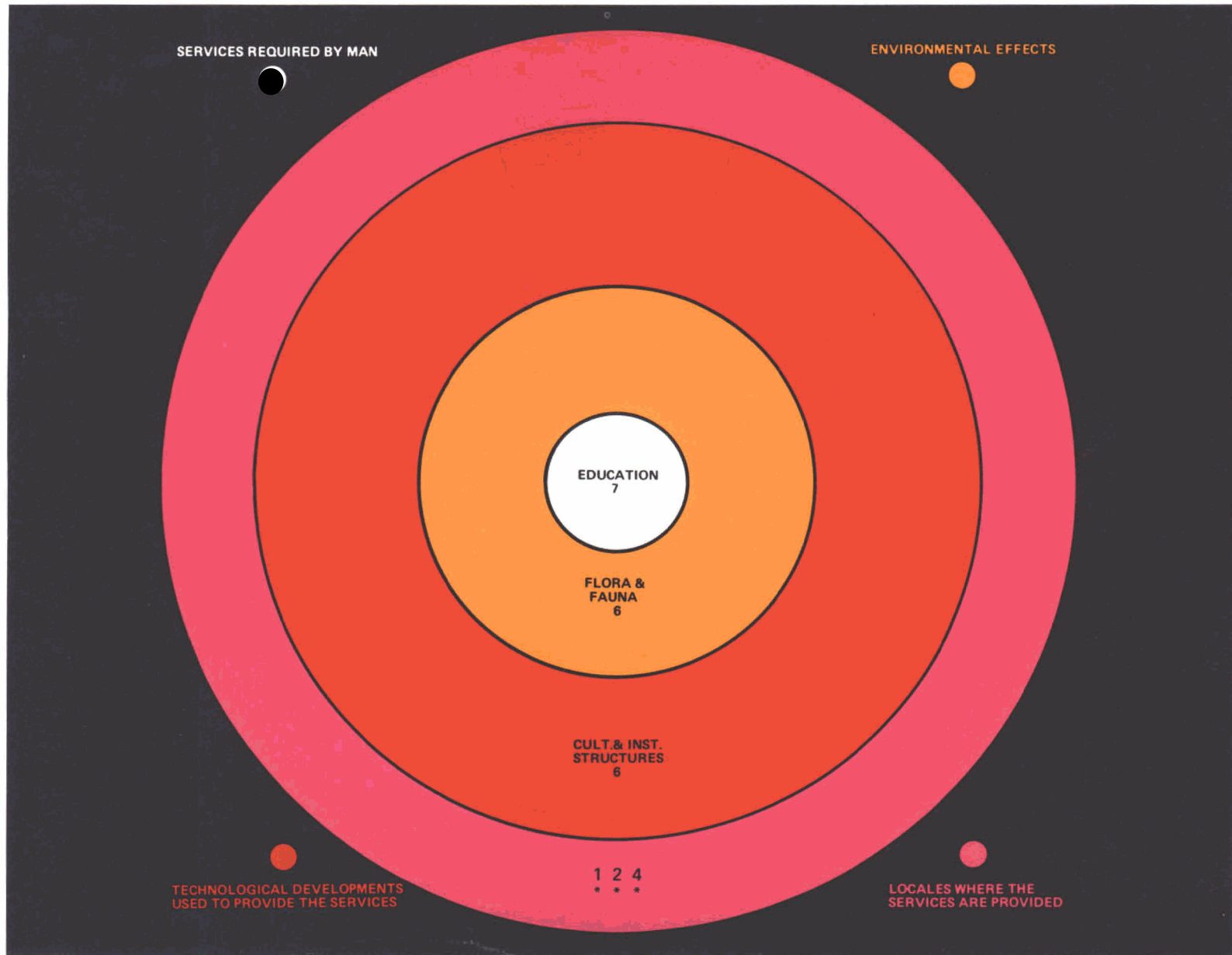


FIGURE 7

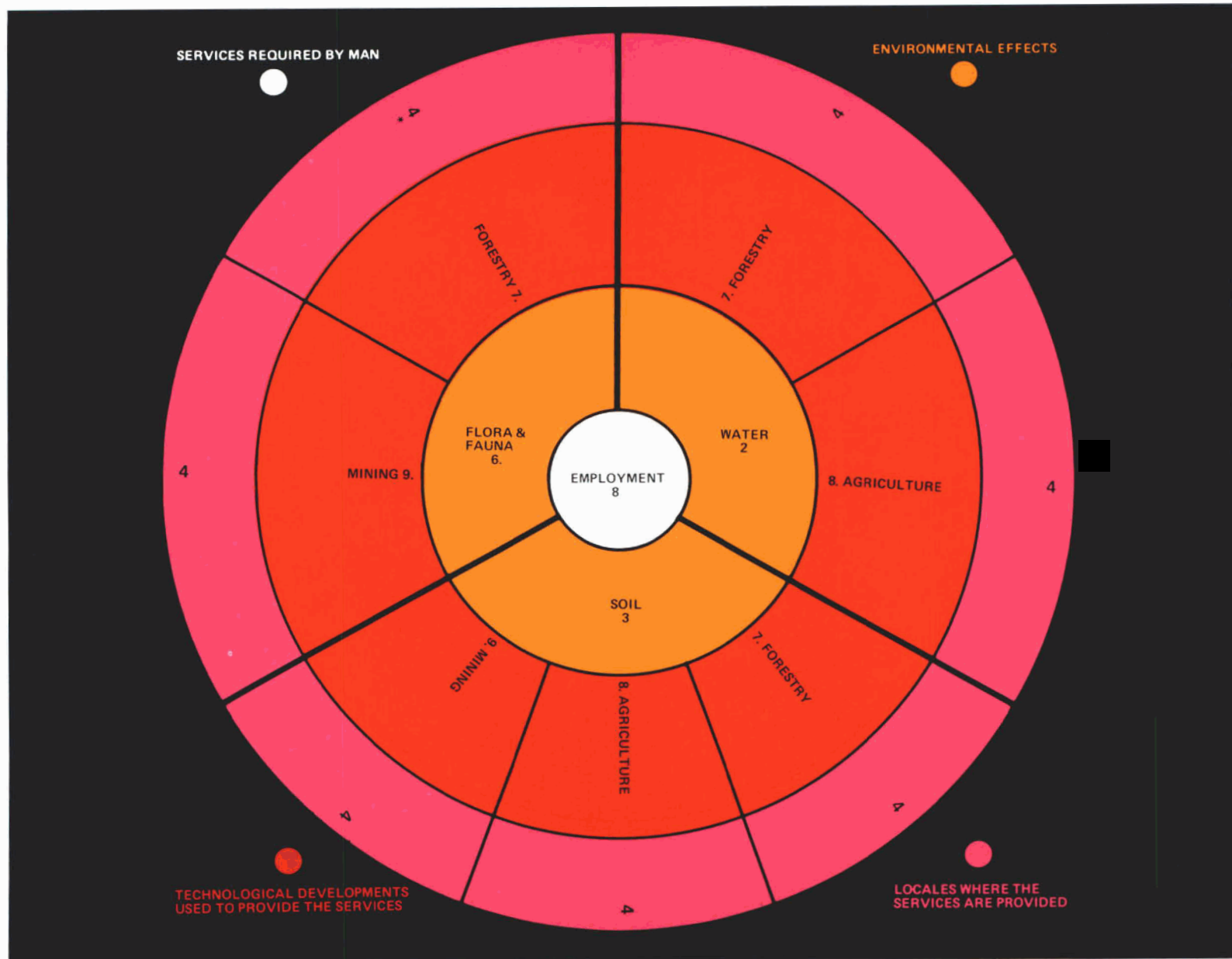
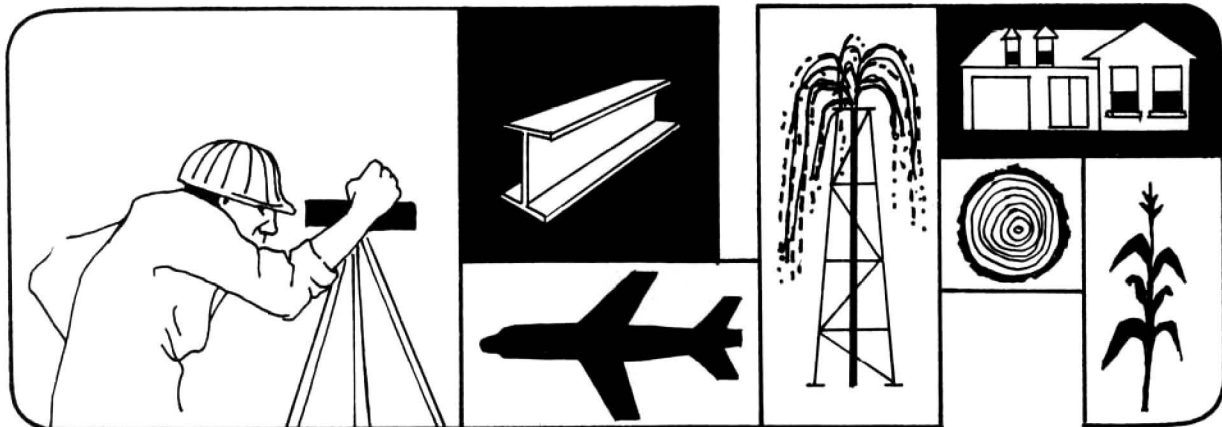


FIGURE 8





SUPPLY — RESPONSE VIEWPOINT



Second, the system can be seen from the perspective of the technologist, planner, industrialist, or engineer who must supply man's services through technological developments. This area of interest involves an assessment of the effects of present and future technology on various environmental forestry situations; in other words, measuring the impact of man on his environment.

Examples of major concern within the various development categories (table 1) includes:

- Oil refining
- Mineral processing
- Pulp and paper manufacturing
- Retail outlets
- Shopping centers and malls
- Fossil-fuel electric plants
- Nuclear power plants
- Apartment complexes

- Condominiums
- Single-family dwellings
- Super highways
- Other highways
- Airports
- Sidewalks
- Right-of-ways for pipelines, powerlines, and telephones
- Elementary and secondary schools
- Colleges and universities
- Parks
- Cemeteries
- Public and private land holdings
- Farms
- Strip-mining

When a supply-response point of view is of major interest, the system can be broken into figures 10 to 17 by starting initially with the developments column in table 1. The system flow in this case can be coded:

DEVELOPMENTS ► EFFECTS ► SERVICES ► LOCALES

Developments begin the flow, and they are subdivided by environmental effects, services, and finally location. For each development in figures 10 to 17, relevant relationships among

environmental effects and developments in particular locations are shown where natural vegetation management may ameliorate adverse environmental effects.

**THE SYSTEM FROM A
SUPPLY-RESPONSE VIEWPOINT**

A given technological development appears in the center of each figure. Interrelated environmental effects, social services, and locale packages are flow-charted outward from the center by relevant groupings.

Locales shown on the outer rim of each figure are coded as follows:

1. Urban
2. Suburban
3. Exurban
4. Rural

An asterisk identifies high-priority packages. For example, in figure 11 the DEVELOPMENT-EFFECT-SERVICE-LOCALE package labeled 3-5-2-2 is a high-priority package.

ARRANGEMENT OF THE SYSTEM FROM A SUPPLY RESPONSE VIEWPOINT

TECHNOLOGICAL DEVELOPMENTS USED TO PROVIDE THE SERVICES

1. HEAVY INDUSTRY
2. LIGHT INDUSTRY
3. POWER
4. RESIDENCES
5. TRANSPORTATION
6. CULTURAL AND INSTITUTIONAL STRUCTURES
7. FORESTRY
8. AGRICULTURE
9. MINING

ENVIRONMENTAL EFFECTS

1. AIR QUALITY
2. WATER
3. SOIL
4. TEMPERATURE AND HUMIDITY
5. NOISE
6. FLORA & FAUNA

SERVICES REQUIRED BY MAN

- PHYSICAL INFRA-STRUCTURE
1. WATER SUPPLY & WASTE DISPOSAL
 2. ENERGY PROVISION
 3. TRANSPORTATION
 4. HOUSING
 5. FLOOD CONTROL
 6. RECREATIONAL STRUCTURES
- INSTITUTIONAL INFRA-STRUCTURE
7. EDUCATION
 8. EMPLOYMENT
 9. HEALTH & WELFARE
 10. RECREATIONAL ACTIVITY

LOCALES WHERE THE SERVICES ARE PROVIDED

1. URBAN
2. SUBURBAN
3. EXURBAN
4. RURAL

FIGURE 10

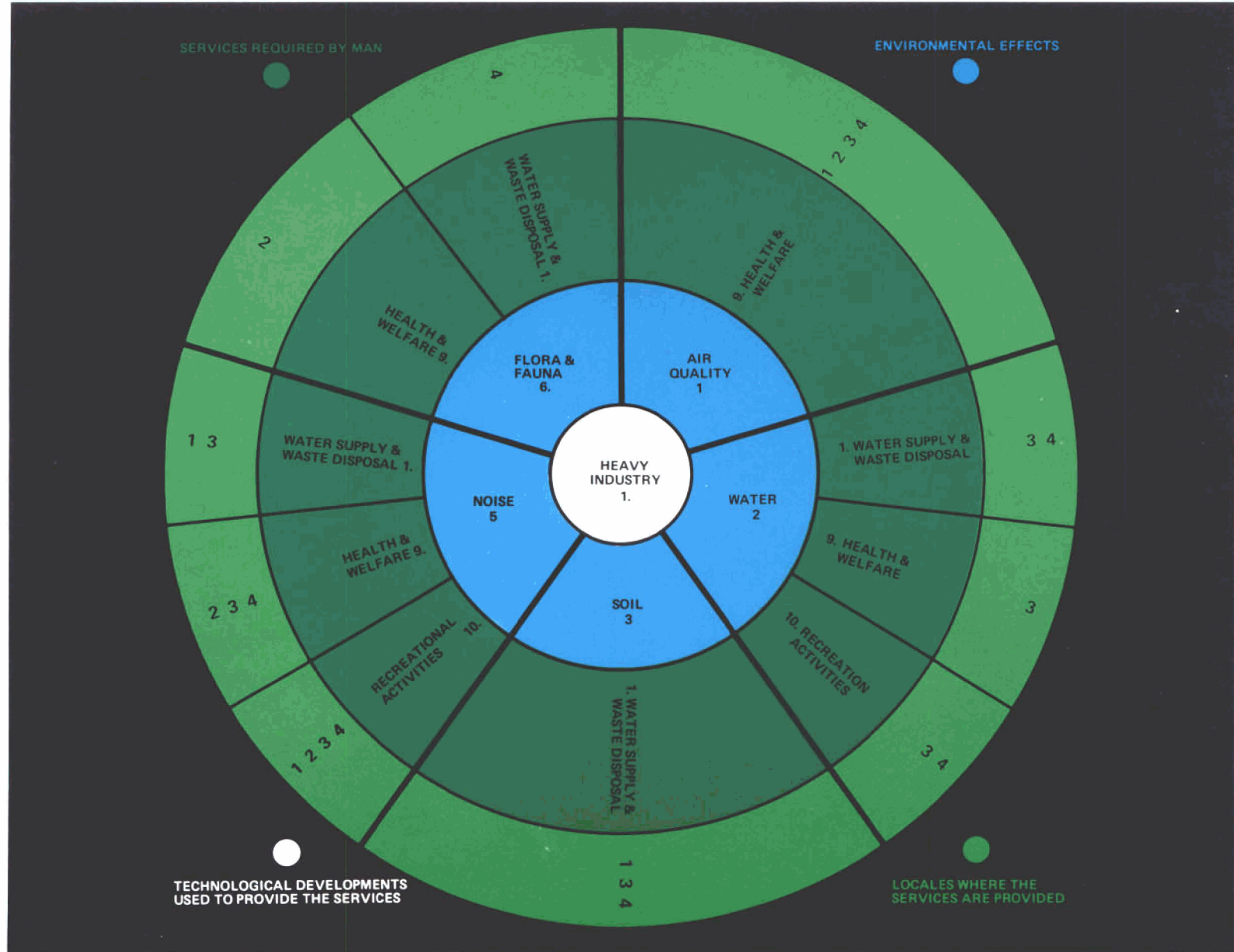


FIGURE 11

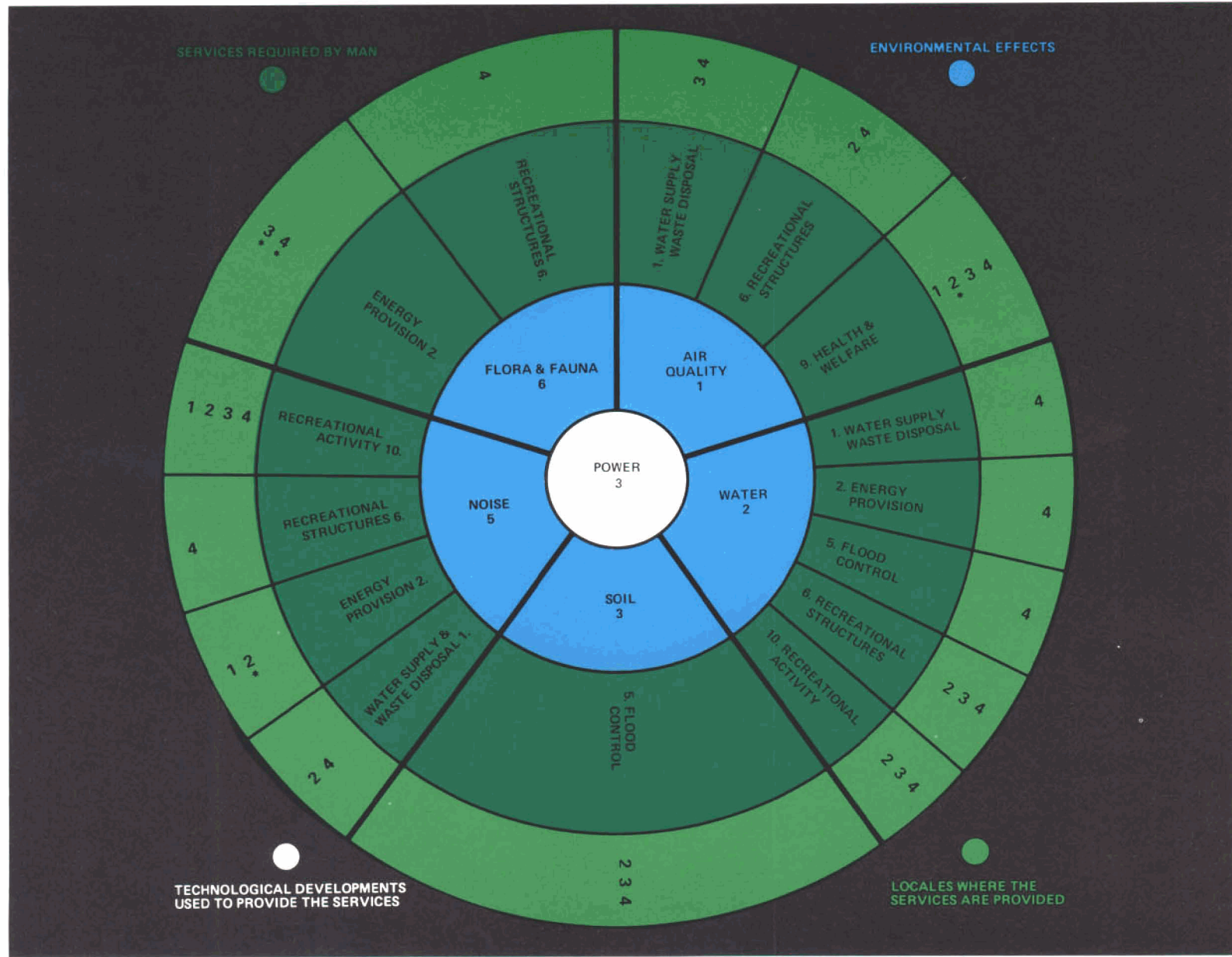


FIGURE 12

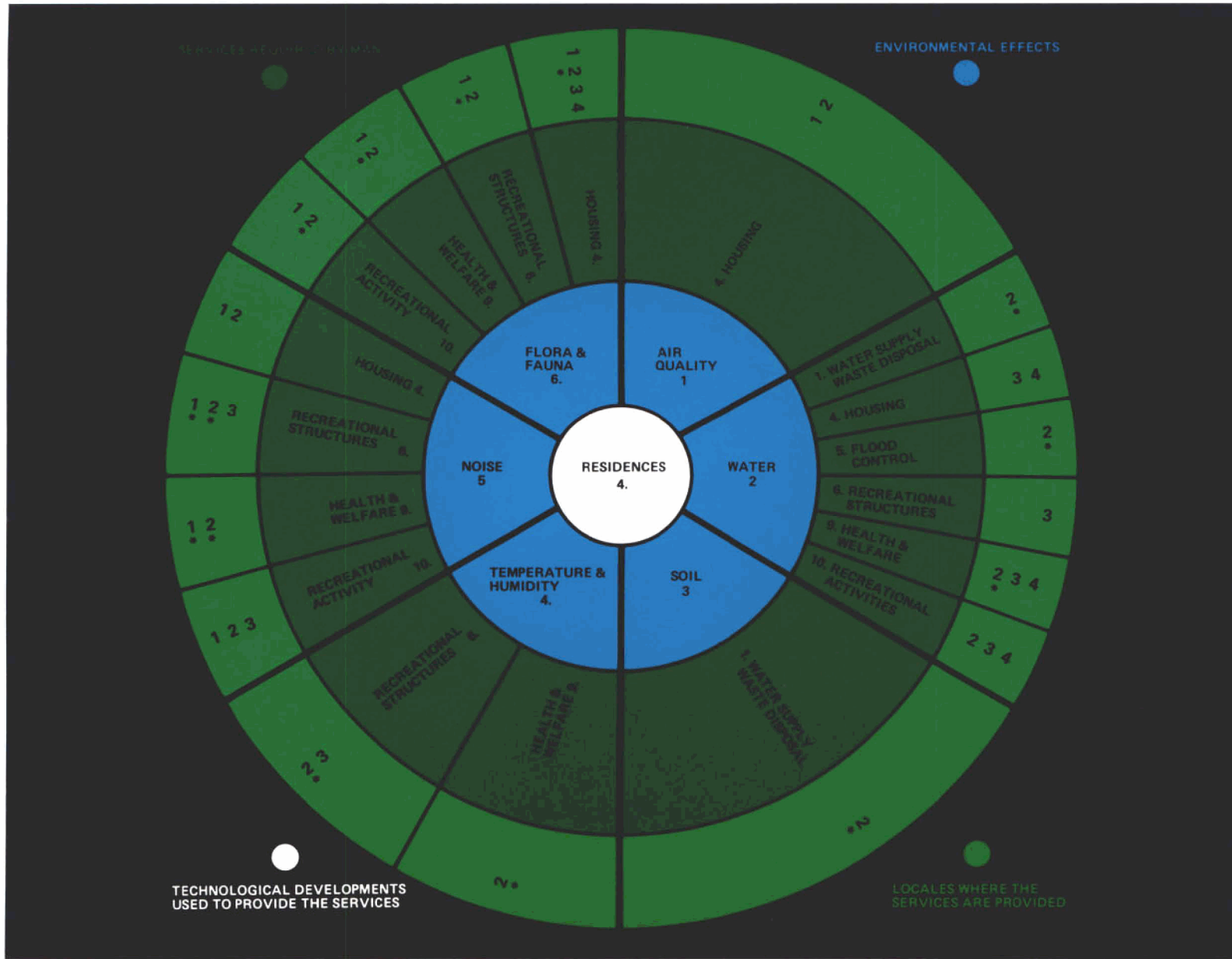


FIGURE 13

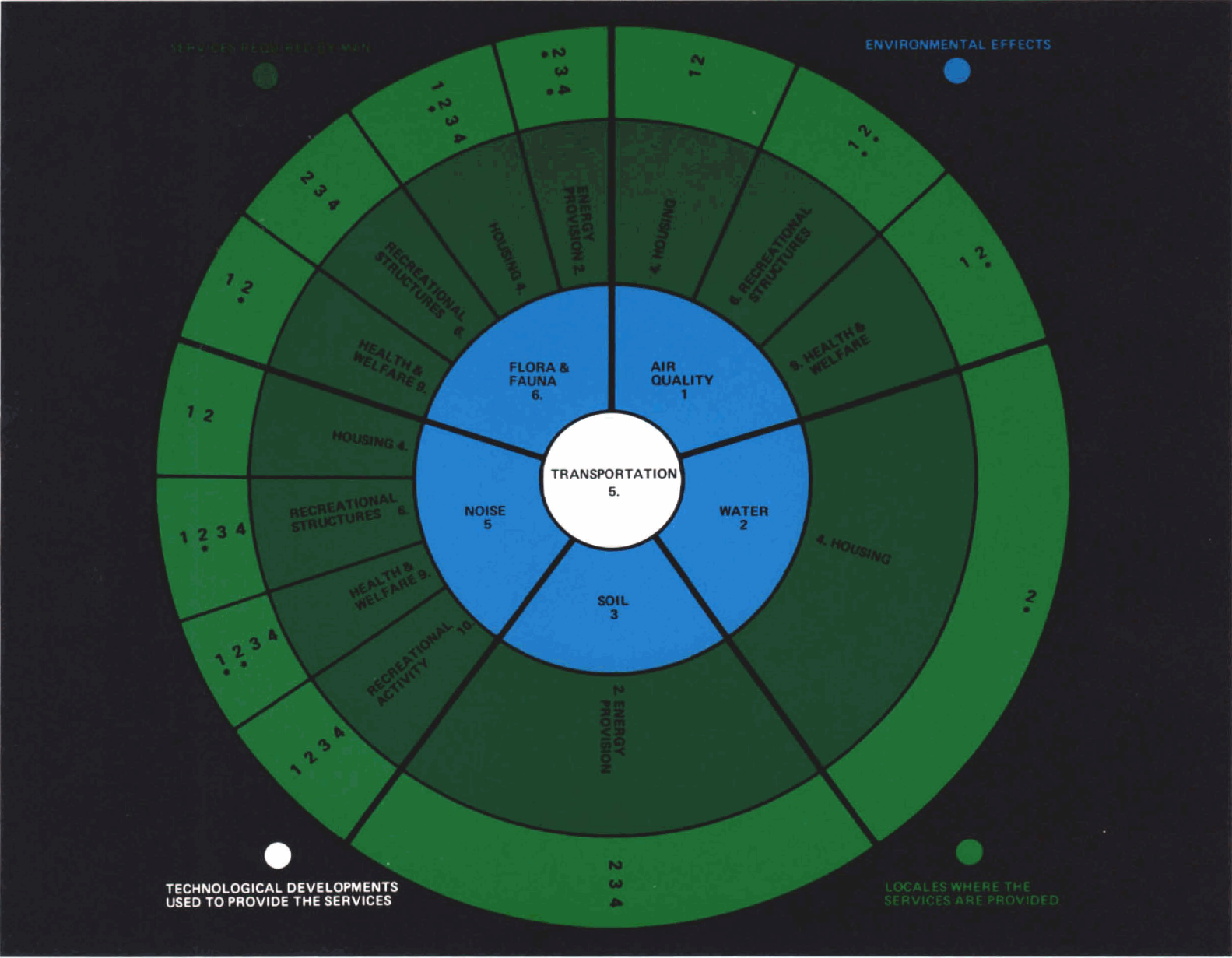


FIGURE 14

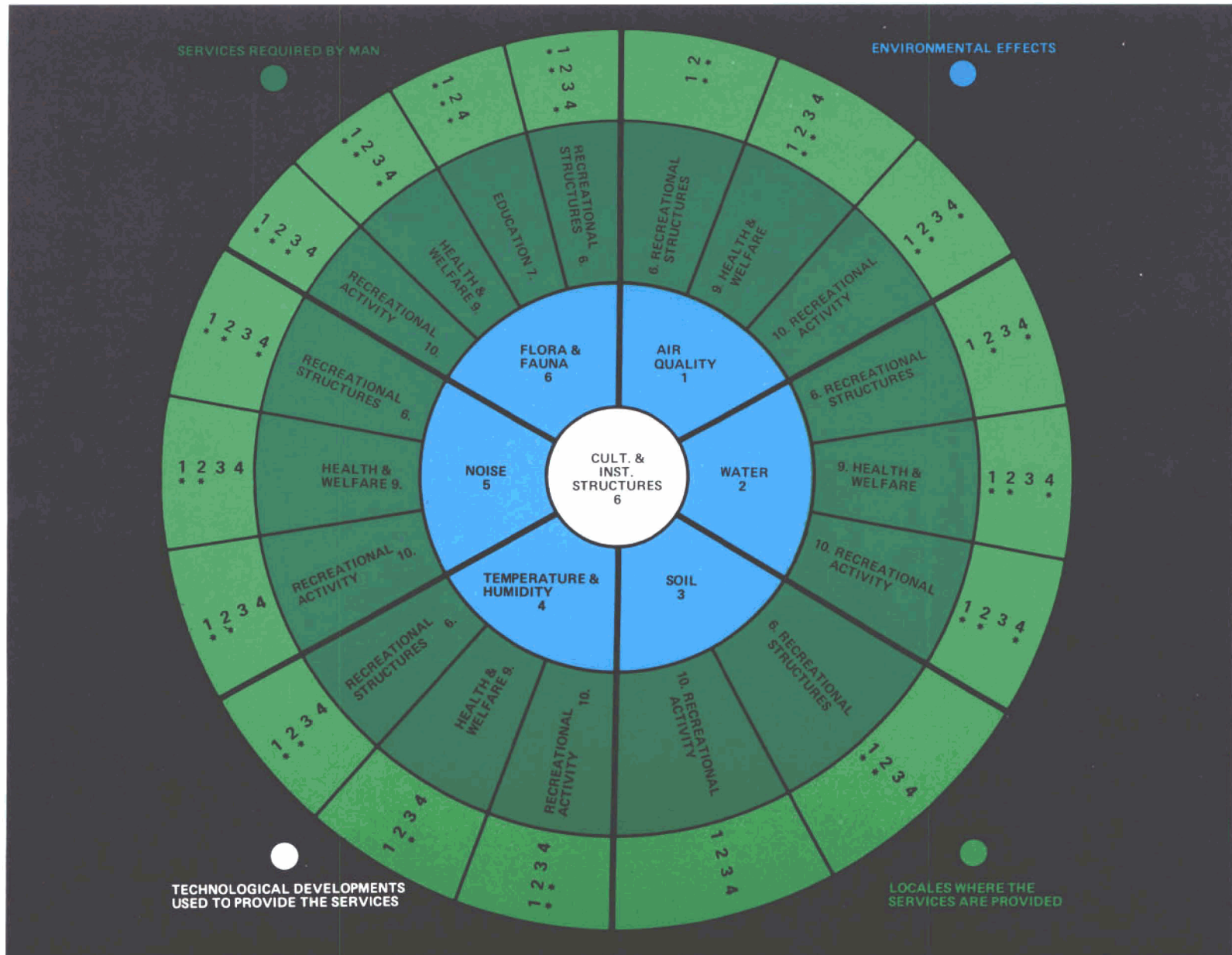


FIGURE 15

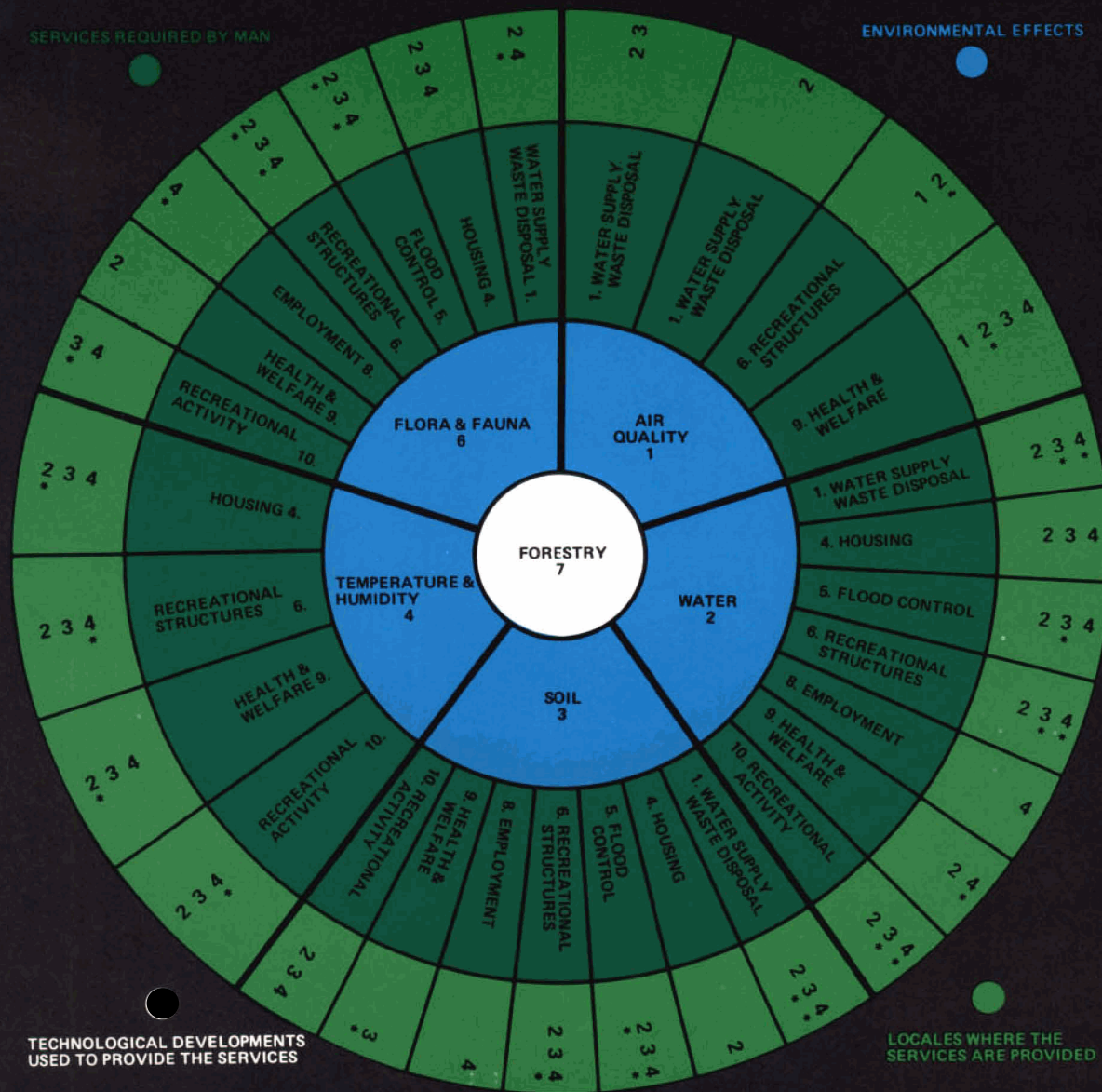
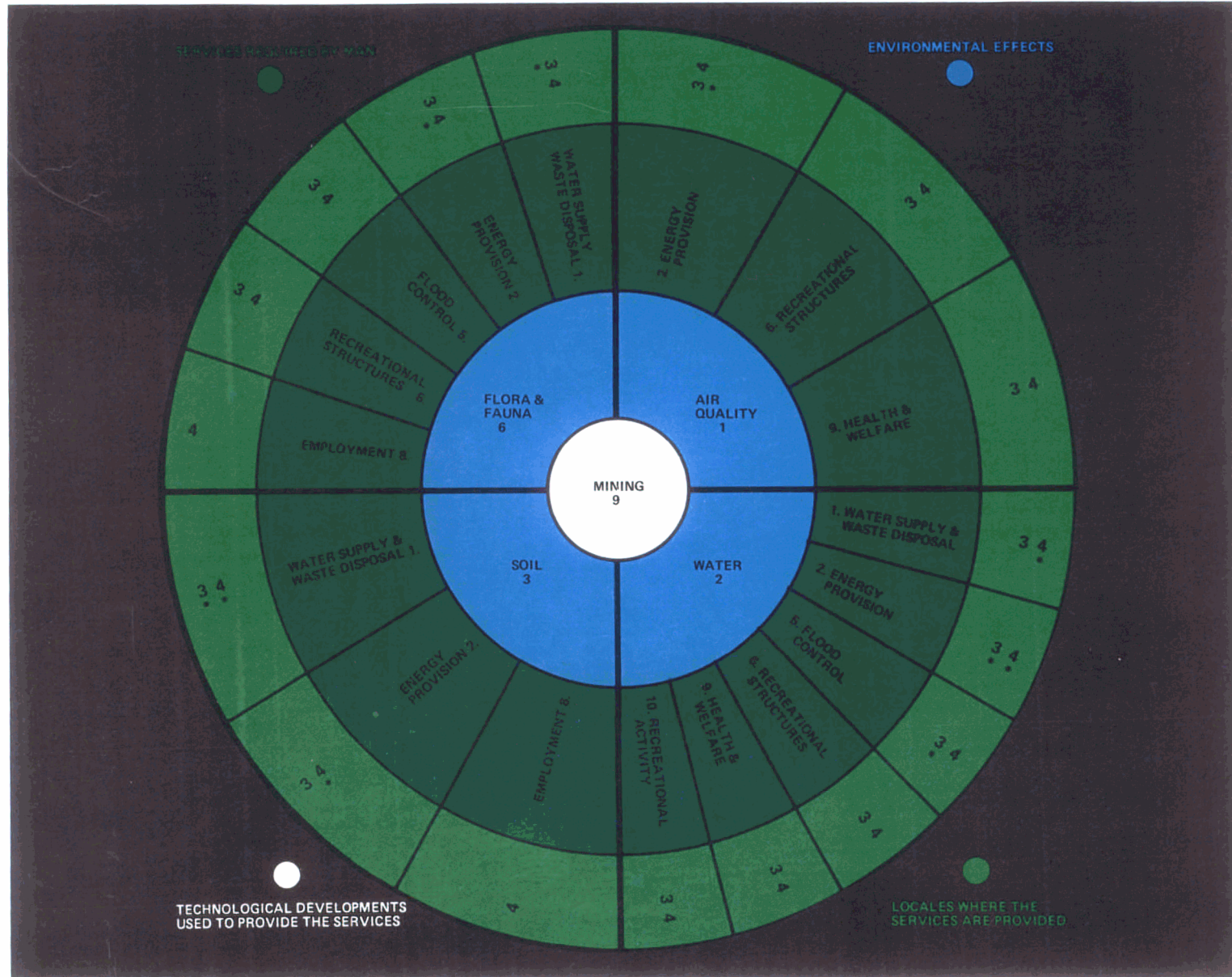


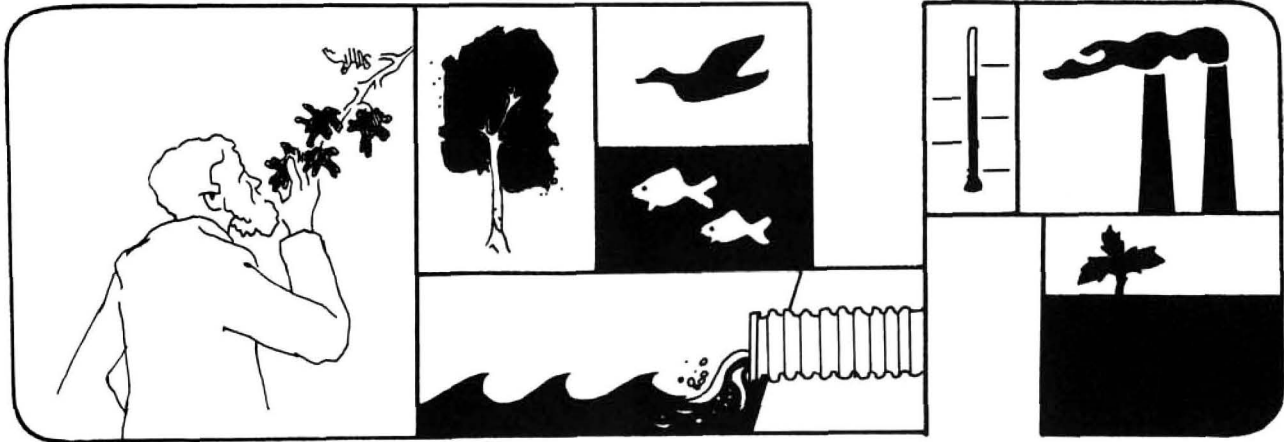
FIGURE 16



FIGURE 17



ENVIRONMENTAL — EFFECTS VIEWPOINT



And finally, the system can be examined from a research-administration perspective or from the viewpoint of the ecologist who is interested primarily in assessing the impact of the environment on man. Associated with one or more of the environmental effects listed in table 1 are such elements as:

- Chemical properties
- Mechanical properties
- Particulate matter
- Odor
- Stability
- Color
- Micro-organism counts
- Water-holding capacity
- Rate of flow
- Turbidity
- Relative humidity
- Precipitation
- Wind speed
- Macroclimate
- Microclimate

- Decibel reduction capabilities
- Overstory density
- Understory density
- Mammals
- Birds
- Insects

Various combinations of all environmental effects contribute to the aesthetic quality of an environment. For this reason, aesthetic quality was not listed as an individual item in table 1. We assumed that the aesthetic quality of an environment results from a composite effect of various components throughout the environmental factors listed under environmental effects. Aesthetic quality needs to be considered in any given combination of the four components of the system.

From the environmental-effect viewpoint, we key first on the environmental-effect column of table 1, and separate the system into six figures, 18 to 23. The system flow in these figures is coded:

EFFECTS ► SERVICES ► DEVELOPMENTS ► LOCALES

Environmental effects are subdivided by services, developments, and finally by locale.

**THE SYSTEM FROM AN
ENVIRONMENTAL-EFFECT VIEWPOINT**

A given environmental effect appears in the center of each figure. Interrelated social services, technological developments, and locale packages are flow-charted outward from the center by relevant groupings.

Locales shown on the outer rim of each figure are coded as follows:

1. Urban
2. Suburban
3. Exurban
4. Rural

An asterisk identifies high-priority packages. For example, in figure 18 the EFFECT-SERVICE-DEVELOPMENT-LOCALE package labeled 1-2-9-3 is a high-priority package.

ARRANGEMENT OF THE SYSTEM FROM A ENVIRONMENTAL EFFECTS VIEWPOINT

ENVIRONMENTAL EFFECTS

1. AIR QUALITY
2. WATER
3. SOIL
4. TEMPERATURE AND HUMIDITY
5. NOISE
6. FLORA & FAUNA

SERVICES REQUIRED BY MAN

PHYSICAL INFRA-STRUCTURE

1. WATER SUPPLY & WASTE DISPOSAL
2. ENERGY PROVISION
3. TRANSPORTATION
4. HOUSING
5. FLOOD CONTROL
6. RECREATIONAL STRUCTURES

INSTITUTIONAL INFRA-STRUCTURE

7. EDUCATION
8. EMPLOYMENT
9. HEALTH & WELFARE
10. RECREATIONAL ACTIVITY

TECHNOLOGICAL DEVELOPMENTS USED TO PROVIDE THE SERVICES

1. HEAVY INDUSTRY
2. LIGHT INDUSTRY
3. POWER
4. RESIDENCES
5. TRANSPORTATION
6. CULTURAL AND INSTITUTIONAL STRUCTURES
7. FORESTRY
8. AGRICULTURE
9. MINING

LOCALES WHERE THE SERVICES ARE PROVIDED

1. URBAN
2. SUBURBAN
3. EXURBAN
4. RURAL

FIGURE 18

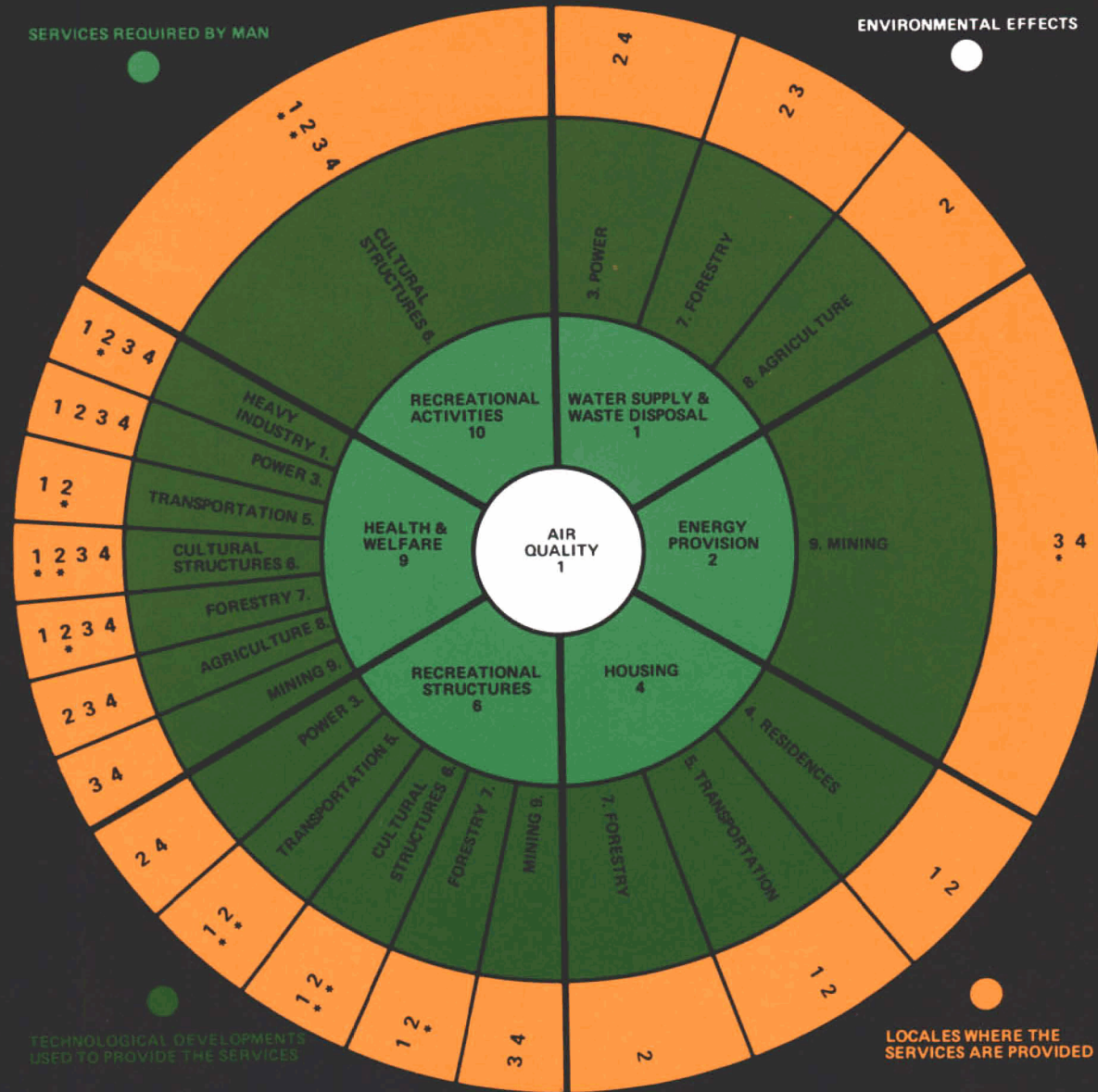


FIGURE 19

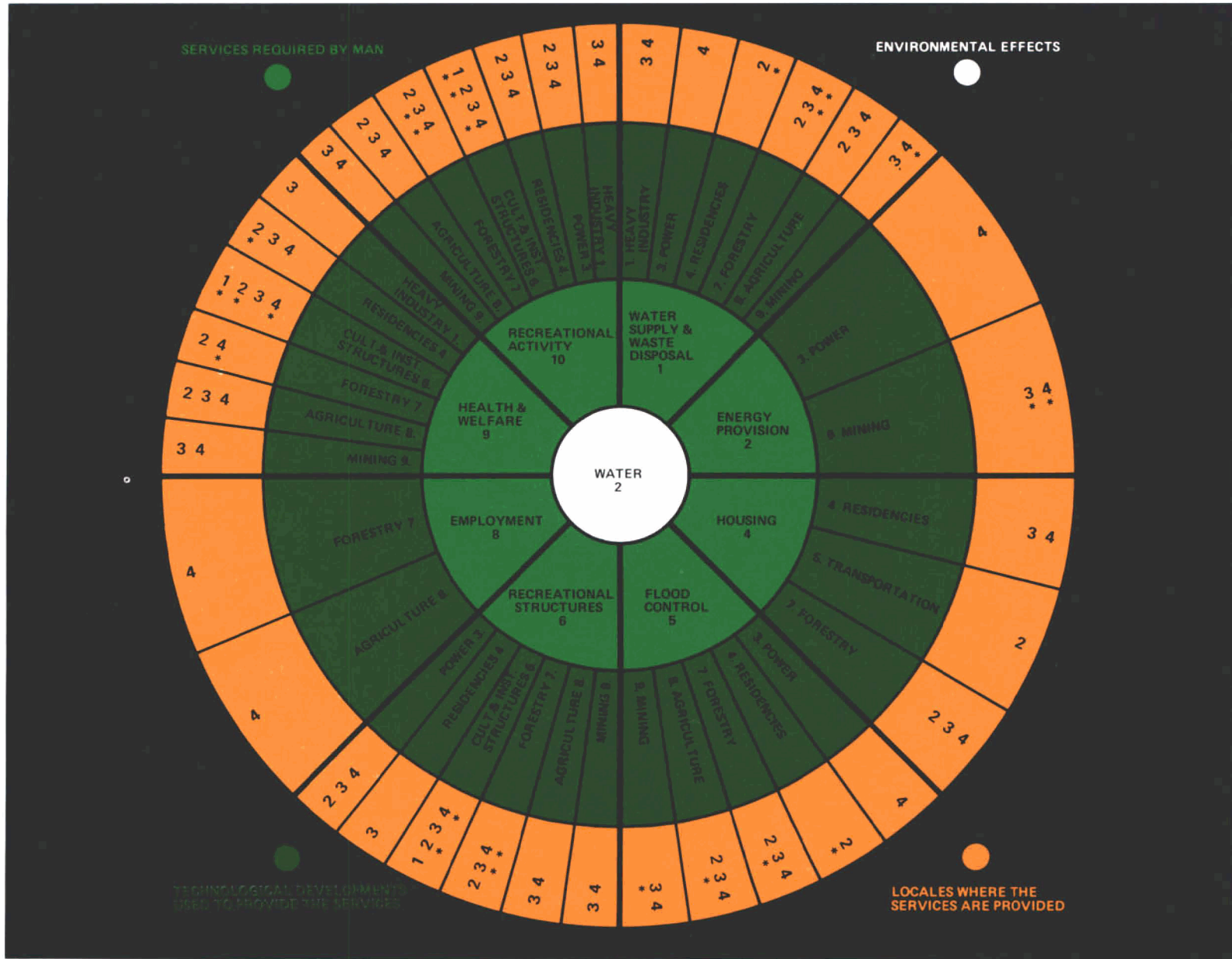


FIGURE 20

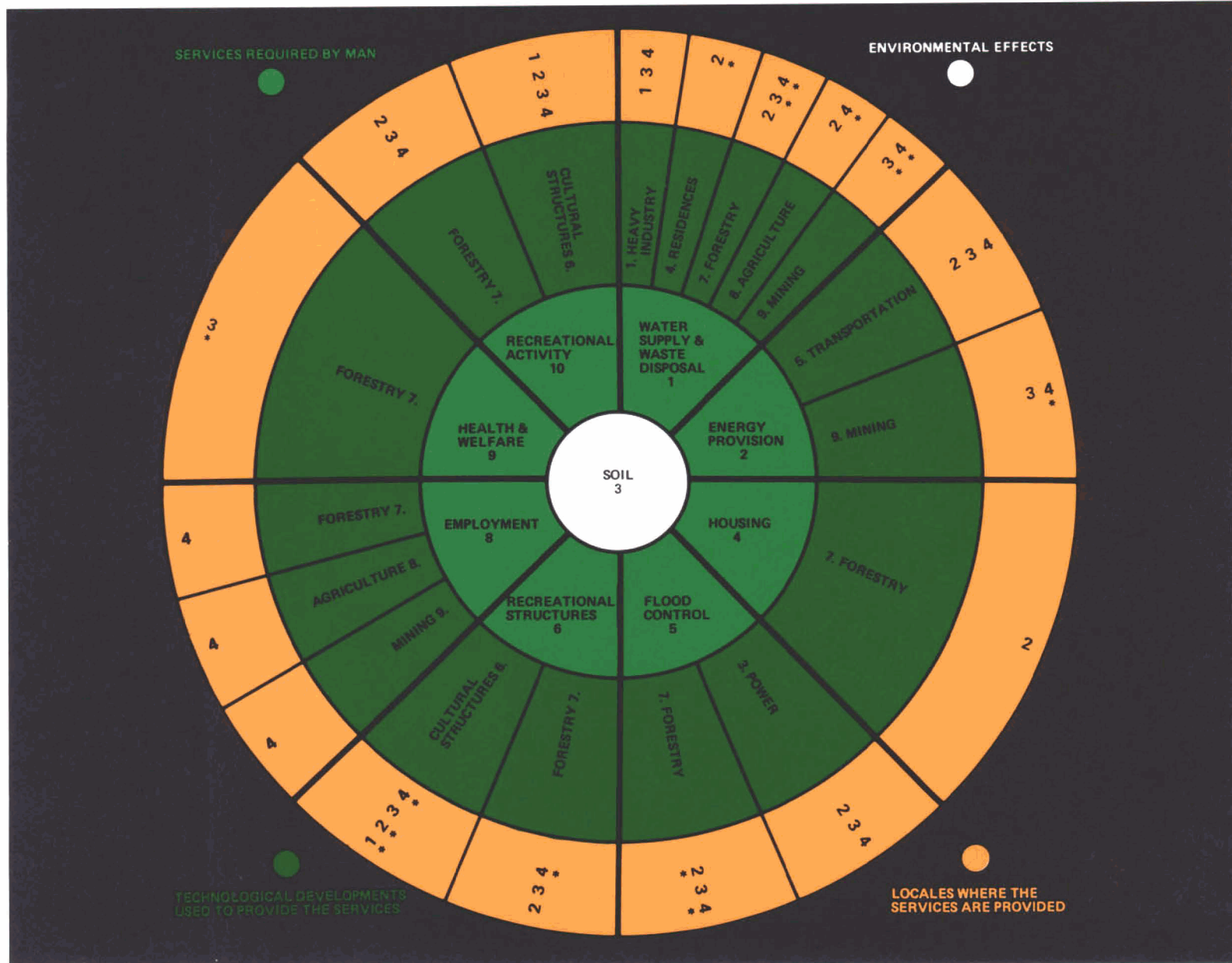


FIGURE 21

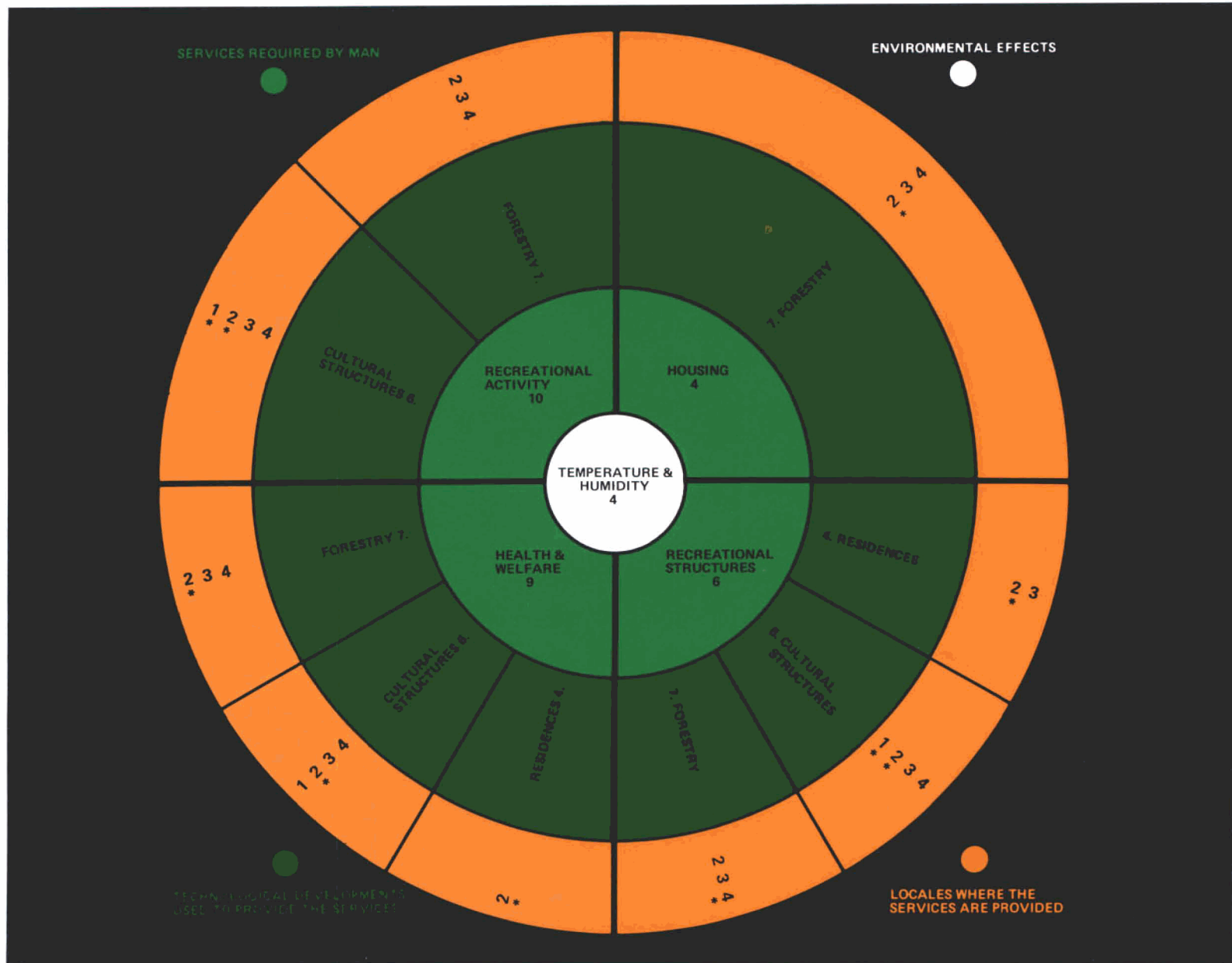


FIGURE 22

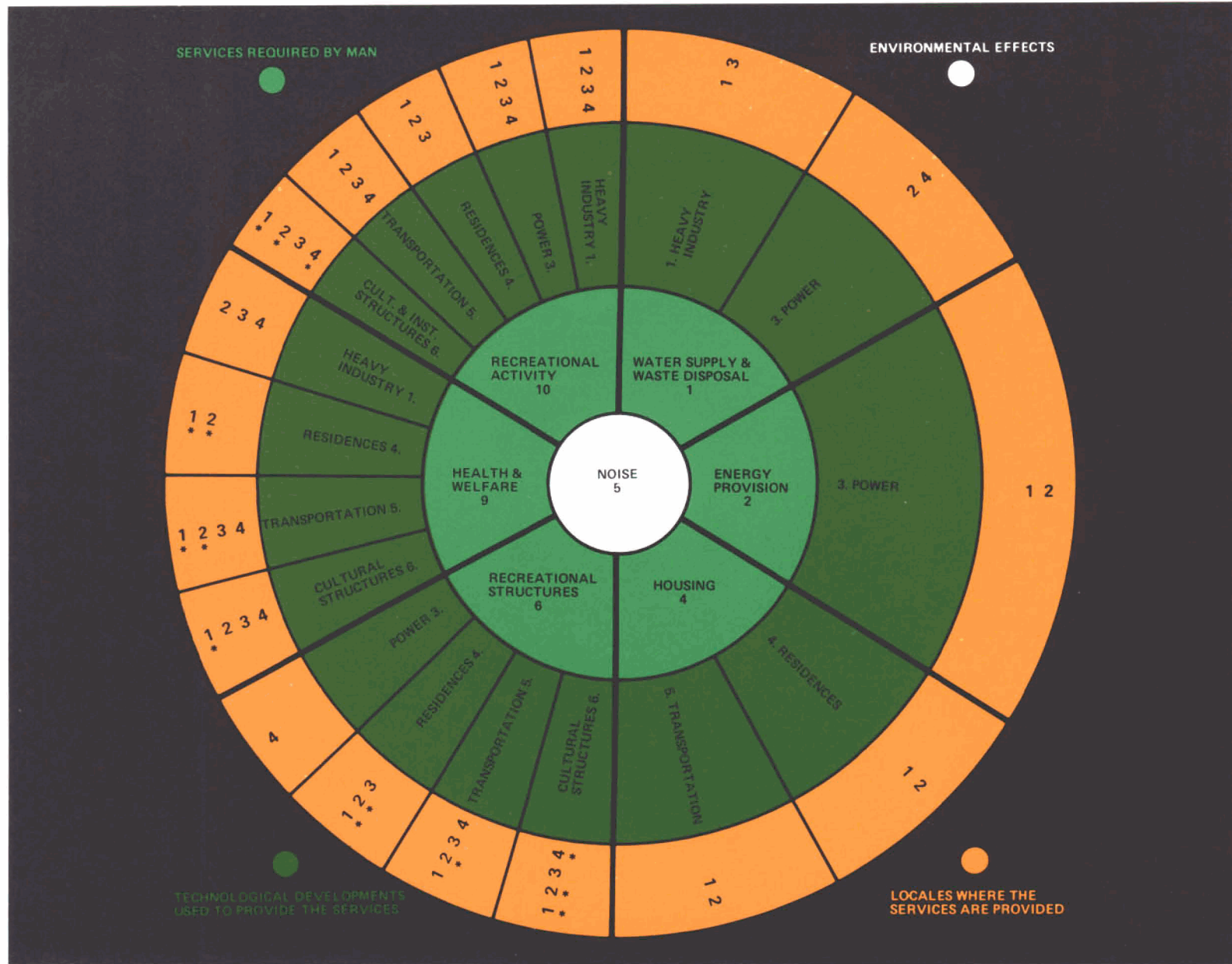
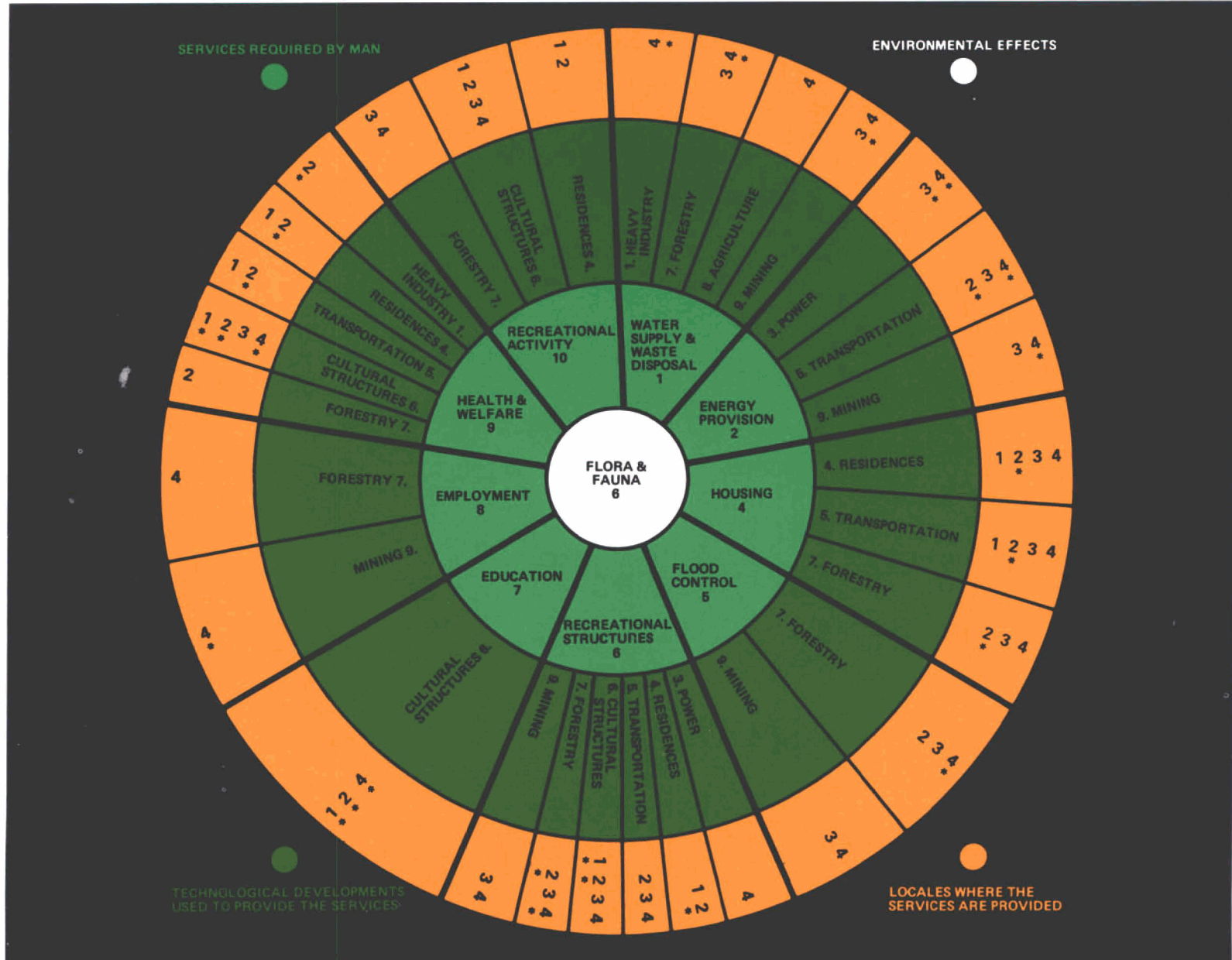


FIGURE 23



SYSTEM FLEXIBILITY

Packaging Research to Meet Each Viewpoint

The overall system can be segmented in various ways to make complete scientific packages that answer a wide range of objectives, depending on the type of decision-maker involved. We may package scientific work along functional research lines; for example, a complete package for water-quality research. We may package scientific work along engineering lines; for example, a complete package for residential developments. We may package scientific work along service lines; for example, a complete package for water-supply and waste-disposal policies.

Traditionally, our research has been organized into discrete scientific fields or disciplines that can be pigeonholed according to parts of the system flow outlined in the environmental-effect viewpoint. The objective of such research has been to dig deeply within a narrow field of study. The environmental-effect viewpoint stresses this objective. It suggests research possibilities within a narrow segment of the total system and enables us to:

1. Evaluate a research study proposal in the context of the total needs within a specific functional or scientific area.
2. Develop a research program in a functional area that will provide input information to the social-needs and supply-response systems.

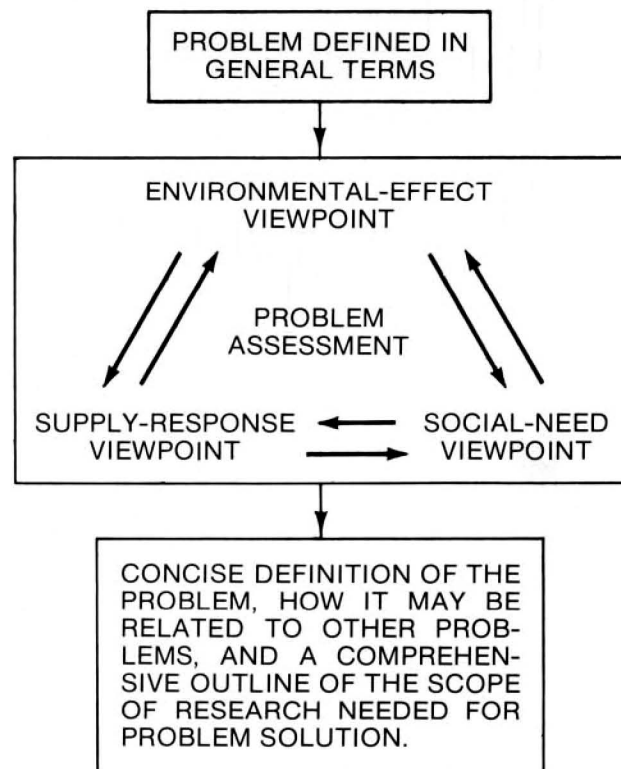
By bringing the social-need and supply-response viewpoints to bear on a given environmental problem, we can evaluate that problem from the position of the decision-maker who is responsible for providing associated social needs or technological developments. Faced with a contemplated development project or program, for example, decision-makers themselves can begin to evaluate resulting environmental effects by looking at the system from their own point of view. Such examinations can provide:

1. An appraisal of the technology involved.
2. An outline of the research required to measure the primary and secondary effect of such technology on natural ecosystems.

3. A relevant outline for preparing an environmental impact statement concerning that same technology.
4. An improved understanding of environmental systems.
5. Knowledge required to permit more effective efforts to prevent environmental degradation.
6. A means through research to accommodate man's activities to environmental constraints.

From their own viewpoints of the system, decision-makers can define the research information input they need. Then, by referring to the environmental-effect viewpoint of the system, these same decision-makers can evaluate a research proposal or suggest what kind of research is needed in terms of their own immediate requirements.

Thus we can generate and reinforce the information required to comprehensively attack a given problem when that problem is subjected to all three viewpoints in this way:



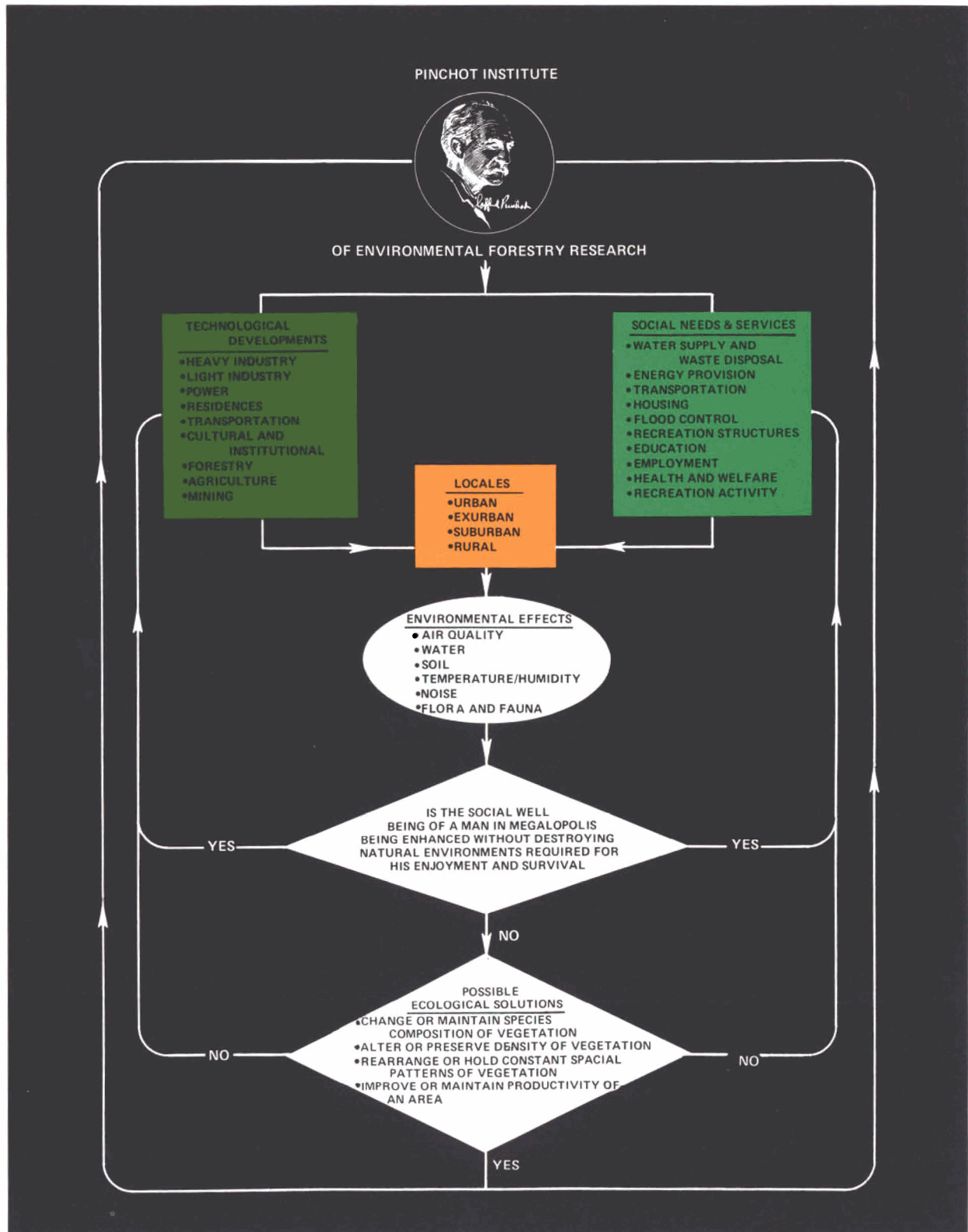
However, in the final analysis of any given problem, the effects of the social and supply innovations will be determined not by the extent to which man can manipulate the external world but by the limitations of the ecosystem (or environmental-effect viewpoint). The ecosystem constraints set the sideboards for the ultimate solution to any given problem. Only in this way will the research approach provide answers that insure the proper functioning of natural ecosystem required for man's ultimate survival in and around Megalopolis.

Who, What, Where, When, Why, and How?

The six questions (who? what? where? when? why? and how?) about research are often difficult to answer explicitly. This system, however packaged, should make answering them easier. The environmental-effects and services components taken together broadly answer the question *what*. The development and locale segments taken together broadly answer *where*. Answers to these two questions go a long way toward determining *how* to conduct the research, although much of the *how* sometimes must (and should) be left to the researcher's ingenuity. Use of the system to indicate relevant combinations shows *why* the work is important. We already know the scientist is going to do the work, and the research administrator says *when*.



A DIAGRAM OF THE ENTIRE SYSTEM



HOW THE SYSTEM WORKS

An Environmental-Effect Approach

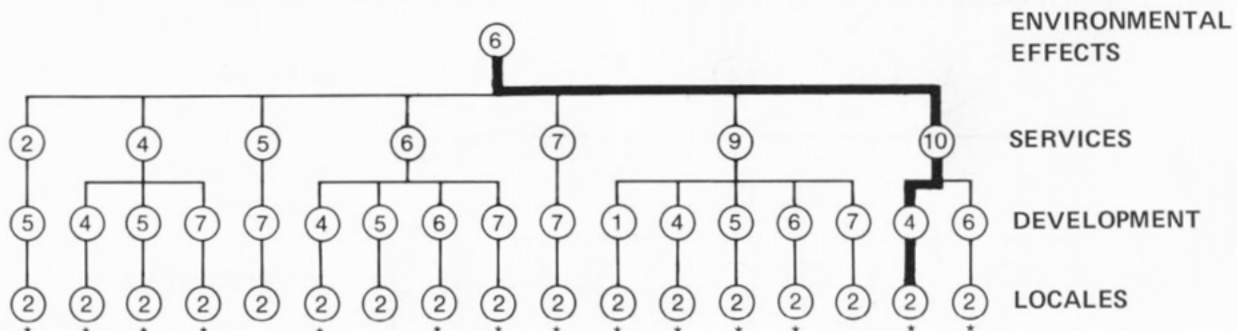
Use of the packages will be illustrated by example, and in this example our primary package will be formulated from the environmental-effect viewpoint. We begin by assuming that a specific research proposal is made to a research administrator, and we trace the administrator's evaluation of the proposal with reference to the complete catalogue of studies in the general area of interest for a specific environmental effect. (The example is kept very simple here simply to illustrate the procedure.)

A scientist proposes studying vegetation manipulation in housing developments in suburban areas so that the results of his research can be used where residents can enjoy certain songbirds and wild animals in suburbia. (Songbirds, incidentally, are also an extremely important factor in natural ecosystems related to man's health and wellbeing.)

Wildlife habitat (flora-fauna) is the central issue here, so we go first to the environmental-effect viewpoint figures, select figure 23 (flora and fauna), and code the research proposal as 6-10-4-2:

<i>Environ- mental Effect</i>	<i>Service</i>	<i>Development</i>	<i>Locale</i>
(flora-fauna)	(recreation activity)	(residences)	(suburban)
6	10	4	2

To place the research proposal in perspective, we chart all other flora and fauna effects in figure 23 that are relevant to suburbia (locale 2). We examine the interconnected parts of figure 23 that are relevant to the environmental effect stipulated in the proposed study. Those parts of that system are:



The number in each circle follows the numbering code for effects, services, developments, and locales found in table 1. An asterisk along the bottom line of numbers indicates a high-priority package. The original proposal in the flow chart is indicated by a heavy line. All other possibilities are shown by light lines.

By evaluating the research proposal in this way, we begin to see how it relates to a complete research program for flora and fauna effects in a suburban setting. By inspection, conclusions can be reached on several important points regarding how the study is related to overall Pinchot Institute objectives:

1. It is in a high-priority package category.
2. It is part of a group of 17 relevant packages or study areas—of which 14 are high-priority packages.
3. Seven suburban services are involved in the total subsystem—services 2, 4, 5, 6, 7, 9, and 10 (table 1).
4. Five developments in suburbs are involved in the total subsystem—developments 1, 4, 5, 6, and 7 (table 1).

For evaluation of a study proposal by a research administrator—and depending upon the ability, qualifications, and experience of the

scientist—one of several recommendations is likely:

1. The proposal is accepted and funded.
2. The proposal is expanded to include other services, such as 4, 6, and 9 as well as 10.
3. The proposal is included in a larger study designed to encompass all 17 relevant study areas.

Recommendation 3 is tantamount to a program-development charge; the research administrator has made a program-development analysis from the flow chart and indicates what to include and where to do it. The first step in program evaluation is taken.

Next, a senior scientist should make an analysis of the problems within the program to determine what information is already known and what needs further research.

A Social-Need Approach

Now consider a research problem from the social-need response viewpoint. For example, a

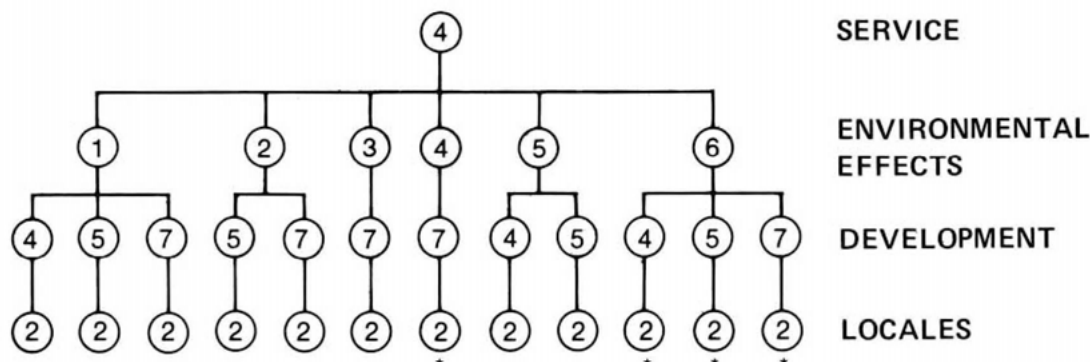
research question from this perspective could be:

In the course of legislating housing needs (service 4) for suburban areas (locale 2), what environmental effects will we encounter that may be ameliorated or protected through policies and programs governing vegetation management? What form of environmental forestry research is needed to develop relevant information for developing policy to regulate housing?

The package code at this point has only two numbers, one for services and one for locales:

Services (housing)	Effects	Developments	Locales (suburban)
4	?	?	2

The missing parts of the package must be supplied to develop a research program. In figure 3, social need number 4 (housing) is selected and traced through the paths (or subsystem) where the two codes (4 and 2) exist. Those parts of that system are:



The number in each circle follows the number system for services effects, developments, and locales found in table 1. An asterisk along the bottom line of numbers indicates a high-priority package.

Therefore, by filling in the missing code numbers so that all the relations can be traced, development of the program proposal for housing in suburbia has begun. Now we can recognize what environmental factors are relevant in this context and what developments they are related to:

1. Research capability in all six environmental categories in this program must be developed.
2. Only three developmental-viewpoint situations are likely to be encountered:
 - a. Residence (4) under three environmental effects areas.
 - b. Transportation (5) under four environmental effects areas.
 - c. Forestry (7) under six environmental effects areas.

- About one-third of the indicated study areas are high priority.

Thus, as in the previous example, the problem dimensions are defined and the relative complexity is determined—clear avenues to problem selections and analysis. The research administrator interested in addressing the enhanced problem package has a point of beginning for determining the expertise and funding needed.

A Supply-Response Approach

In a traditional sense, the importance one should attach to evaluating a given problem in the above manner depends upon the responsibilities of the one making the appraisal. A suburban real-estate developer, using the previous example, has an outline on which to base an environmental impact statement, or on which to make an engineering evaluation of technical alternatives.

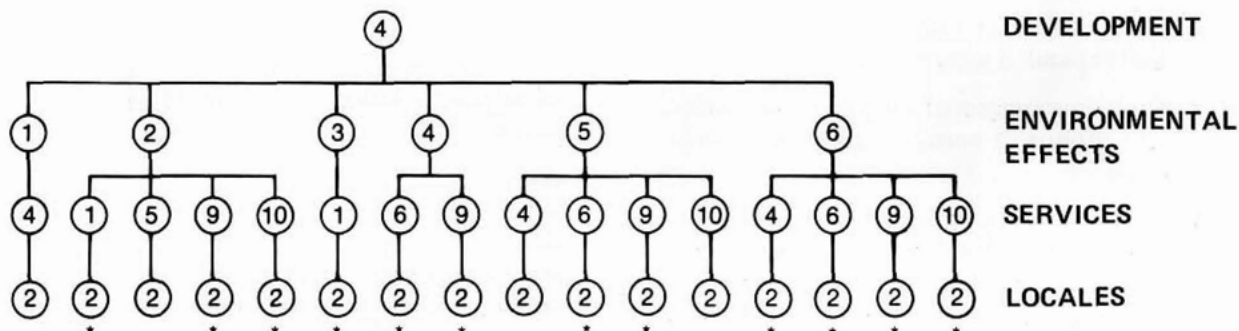
However, the developer—using the supply-response viewpoint—may ask the research question somewhat differently:

In the course of building suburban residences (locale 2, development 4), what effects will such development have on natural systems of the environment that can be enhanced, protected, or avoided through manipulation of vegetative composition, density, patterns, or productivity?

Here the package code is:

Developments (residences)	Effects	Services	Locales (suburban)
4	?	?	2

The missing parts of the package can be supplied by referring to figure 12 (residences) and tracing through the paths (or subsystem) where the two codes (4 and 2) exist. Those parts of the system are:



The number in each circle follows the number system for services, effects, developments and locales found in table 1. An asterisk along the bottom line of numbers indicates a high-priority package.

We conclude from this flow that:

- Capabilities in all six environmental categories are required.
- Six social services are also interrelated with residences:
 - Water supply and waste disposal (1) under two environmental effects.
 - Housing (4) under three environmental effects.
 - Transportation (5) under one environmental effect.
 - Recreational structures (6) under three environmental effects.
 - Health and welfare (9) under four environmental effects.
 - Recreational activity (10) under three environmental effects.
- Three-quarters of the indicated study areas have high priority.

Advantage of Using All Three Viewpoints

A research administrator, using the previous example of how the system works, has an outline to help him evaluate a research proposal or to develop a research program. The research administrator also sees that the wildlife-habitat research program described in the example about an environmental-effect viewpoint could constitute work in 20 to 25 percent of the suburban planner's environmental problems that are amenable to vegetation management. Both

the suburban developer and the policy-maker understand their roles in the total research picture.

Decision-makers from all three viewpoints now have broader based views, and they should be able to communicate their needs and problems with one another much more quickly and surely.

Thus the reinforcing feedback loop of information mentioned earlier for all three viewpoints becomes readily apparent in the total system.

RESEARCH PLANS TO ENHANCE THE SYSTEM

Recognized Weaknesses

The Pinchot Institute recognizes at least nine aspects of this first-generation system for exploratory research and problem evaluation that need improvement:

1. Components in table 1 need to be revised and expanded where necessary.
2. Problems suggested by individual packages and groups of packages need to be defined explicitly.
3. Where answers to parts of problems already exist, results should be published in concise, compact form for use by decision-makers. In this same regard, a continuous literature review is required to update and publish supplements to the initial reports.
4. Dependent and independent variables in each problem, or associated problems, need to be clarified.
5. Parallel and interconnecting links among and within the major components of the system need to be explored in preliminary pilot research studies.
6. Preliminary research studies are needed to adequately assess the need for concentrated research at given points or interconnecting sections of the system.
7. With the exception of a somewhat gross attempt to set priorities, a weighting procedure needs to be developed within the total system for allocating limited research funds and manpower.

8. As the system becomes more complex, retrieval computer procedures will need to be developed that will allow a given management problem to be defined from all three viewpoints and to print out either the location within the Consortium where the expertise exists to solve the problem or the references in the literature where the total or partial solution to the problem can be found.

9. As information about the total Pinchot Institute system becomes available, multidisciplinary teams need to model the research-allocation system for a variety of environmental problems. Such an approach should eventually provide an optimum combination of packages that could be funded according to an expected payoff matrix of results.

Multidisciplinary Team Approach

Multidisciplinary research teams have been established within the Pinchot Institute's Consortium of universities and inhouse research units to attack the nine basic weaknesses mentioned above. With the capability to utilize the expertise of many disciplines that exist throughout its nine leading institutions, the Institute's Consortium can create almost any type of multidisciplinary team that may be required to solve environmental forestry problems throughout Megalopolis. The Consortium has the physical plant capabilities to comprehensively and quickly engage in research to

answer the ecological-oriented problems of metropolitan planners and developers.

Starting with a given viewpoint, each team examines groups of research packages within various parts of the total system. Examples of elements to be considered by teams using each viewpoint have been listed previously in the

descriptions of those three viewpoints. When a team is satisfied that it has considered most of the important dependent and independent variables of interest, the framework for writing a problem analysis and for developing individual research studies becomes fairly straightforward.

APPENDIX I

CHARTER OF THE CONSORTIUM FOR ENVIRONMENTAL FORESTRY STUDIES

The great wave of concern about the human environment, now sweeping across the Nation, relates in part, as it has historically, to forest values in both rural and urban America.

Various public agencies and private groups are studying bits and pieces of the complex influences, interactions, and contributions of forest resources to the human environment. Many Universities and State Agricultural Experiment Stations are studying how forests and their components are affected by man's actions and, in turn, how they affect man itself. Similarly, the Forest Service, U.S. Department of Agriculture, is conducting studies in this field.

The challenge to these research agencies to find means of obtaining the optimum contribution from forest resources in and around densely-populated areas is both large and complex. And the challenge of a cohesive, coordinated research effort is too large for a single university or agency, but, through local complexity, poorly suited to a national institute. It is best attacked through a concerted effort by a regional association of agencies and institutions capable of conducting significant investigations on a coordinated basis.

The Pinchot Institute of Environmental Forestry Research, a multifunctional division of the Northeastern Forest Experiment Station, was created by the Forest Service to meet these challenges in northeastern United States. The Institute serves as a catalyst and a focal point for the scientific capabilities of a consortium of interested universities and the Forest Service brought together to solve environmental forestry-research problems of the urban-forest interface in and around the eastern Megalopolis. The Institute is the vehicle through which substantial Forest Service research grants are made to universities cooperating within the framework of the university-Forest Service Consortium.

The Consortium is organized to coordinate research activities of participating members. It will develop the knowledge and technology

needed to solve problems of policy formulation, regional planning, and land management related to environmental forestry in and around eastern population centers. It will provide for dissemination of research results in a coordinated program designed to acquaint people throughout the area with the role of forests in maintaining and improving the quality of human environment. And it will serve to attract other sources of cooperation, participation, and funds.

The Charter, which follows, will guide the operations of the Consortium.

ARTICLE I. *Name and Location*

The name of this consortium shall be CONSORTIUM FOR ENVIRONMENTAL FORESTRY STUDIES. The principal office shall be at the Forest Service, U.S. Department of Agriculture, Northeastern Forest Experiment Station, Upper Darby, Pennsylvania.

ARTICLE II. *Purpose*

This nonprofit Consortium is formed to initiate, support, and carry out programs of research and associated graduate education relating to the urban-forest interface in the Megalopolis of the northeastern United States; to establish, maintain, and operate such facilities as may be needed to carry out these missions; to publish and otherwise disseminate the results of research; and to carry out other activities as needed in furthering these endeavors.

Research will include, but is not limited to, the following general areas:

1. Improving decision making and planning models involving social, economic, biological, and ecological analysis of forest resources in areas of constantly increasing human pressures.
2. Increasing the amenities provided by forest resources.

3. Improving the management of forested municipal watersheds for urban water supplies, recreation, and other uses.
4. Genetic improvement of intensively used forest vegetation.
5. Site requirements for landscape tending.
6. Improving wildlife habitat for spectator enjoyment, with emphasis on nongame species.
7. Improving the social wellbeing of urban people through recreation and aesthetics in a forest environment.
8. Improving the management of urban-forest ecological systems.
9. Improving the protection of high-value forest vegetation from destructive actions of man and other agents.
10. Improving urban highways and intersections with forest vegetation.
11. Improving urban man's understanding of his interrelationships with, and determining his needs for, urban forest environments.
12. Improving social institutions and arrangements for using forest resources to improve the urban environment.

ARTICLE III. *Membership*

The Consortium for Environmental Forestry Studies shall be composed of the Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, and selected educational institutions within the eastern Megalopolis and the territory of the Northeastern Forest Experiment Station which have programs directly related to environmental forestry. The charter educational institutions are: University of New Hampshire, Durham, New Hampshire; Massachusetts Agricultural Experiment Station, Amherst, Massachusetts; University of Connecticut, Storrs, Connecticut; Yale University, New Haven, Connecticut; State University College of Forestry, Syracuse, New York; The Cornell University Agricultural Experiment Station, Ithaca, New York; Princeton University, Princeton, New Jersey; Rutgers University, New Brunswick, New Jersey; and Pennsylvania State University, University Park, Pennsylvania. Additional educational institutions may be invited

to join the Consortium following procedures established in the bylaws.

No fee shall be required for institutional membership in the Consortium.

An institutional member may resign at any time by giving 90 days written notice to the Consortium. Forest Service membership shall continue as long as the companion Cooperative Agreement between the Forest Service and the Consortium remains in force.

ARTICLE IV. *Obligations of Member Institutions*

A. Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, agrees to:

1. Provide funding as permitted by Congress and appropriate budget authorities for the purpose of undertaking research described in Article II within the framework of the Pinchot Institute for Environmental Forestry Research. The Forest Service will, furthermore, undertake with its own staff and facilities, research conceived to meet the objectives of research described in Article II in the amount in value of approximately one-half of the funds allocated to the Institute for research. The other half of the funds allocated to the Institute shall be made available under separate agreements supporting research proposed by member educational institutions or by other educational institutions and which meet the objectives of the Consortium described in Article II.
2. Furnish annually to the Executive Committee of the Consortium, as early in the fiscal year as reasonable assurance can be given, the approximate amount of funds that will be available that year for research grants that meet the objectives of the Consortium.
3. Designate a representative to serve full time on the Executive Committee of the Consortium for continuing liaison and coordination of the entire research program of the Pinchot Institute for Environmental Forestry Research.

4. Provide logistical support in the form of secretarial and office services and supplies to the Consortium within the limits imposed by the funds and personnel administratively determined to be available for this purpose.
5. Participate fully with members of the Consortium in research problem identification and selection and research program formulation for both university and in-house research.
6. Share the cost of Consortium publications as appropriate and mutually agreed in each case.
7. Serve, participate, and contribute to all Consortium activities as mutually agreed upon by the Consortium as a whole, and to the extent permitted by Federal laws and regulations.

B. Each member Educational Institution agrees to:

1. Participate fully within the Consortium in research problem formulation for both university and Forest Service in-house research.
2. Serve and participate in all Consortium activities as mutually agreed upon by the Consortium as a whole.
3. Fund the cost of sending representatives to the annual technical and committee meetings agreed to by the Consortium. Travel policies of each institution shall control its official representative or alternate; each institution shall pay only for its own representative.
4. Publish or arrange for publishing appropriate results of the research sponsored through the Consortium and conducted by a member of the institution, according to the policies and practices of the educational institution concerned and giving due credit to the Pinchot Institute for Environmental Forestry Research for funding any grants it provides that are involved in the research reported.
5. Share the cost of general Consortium publications as appropriate and mutually agreed in each case.

ARTICLE V. *Organization*

A. *Consortium:*

Each member institution, including the Northeastern Forest Experiment Station, shall designate one official representative and one alternate representative to the Consortium. The alternate representative shall vote only in the absence of the official representative. An institution is not obliged to cause its alternate to attend any meeting unless its official representative does not attend. The alternate, however, is permitted to attend.

B. *Officers:*

The official representatives to the Consortium shall elect annually from their membership a president, a president-elect, a vice-president for research, and a secretary-treasurer. The Forest Service representative shall not be eligible to serve as an officer.

The President shall be empowered to ratify decisions of the Executive Committee by executing instruments and other papers in the name of the Consortium. Other responsibilities and authorities of the officers not otherwise described in the Charter shall be proposed by the Executive Committee and become effective when adopted by amendment to the Charter or the bylaws.

C. *Executive Committee:*

The Executive Committee of the Consortium shall consist of the above four officers plus a member of the Forest Service appointed by the Director of the Northeastern Forest Experiment Station plus a non-voting recording secretary provided by the Forest Service.

The Executive Committee shall be empowered to handle the business and affairs of the Consortium and to appoint and assign duties to such standing and ad hoc committees as may be advisable. The Executive Committee is not empowered to bind any institution to make any payment of funds or render any services to the Consortium or any third party. Actions of the Executive Committee shall be consistent with this Charter and the votes of its members. A four-fifths majority of the Executive Committee is required to initiate any action.

ARTICLE VI. *Funding*

It is expected that the principal source of funds to support research planned by the Consortium will be Federal appropriations to the Forest Service, U.S. Department of Agriculture, available for this purpose. In addition, the Consortium will accept funds from other appropriate organizations, agencies, and foundations. All proposals for funds sought in the name of the Consortium will be reviewed by the Consortium Executive Committee, which will approve or disapprove them. Member institutions may seek funds individually, without review by the Executive Committee, if such funds are not sought in the name of the Consortium.

ARTICLE VII. *Operations*

A. *Internal Administration*

1. *Annual Meeting.* The Consortium shall meet at least once a year at a time and place decided by the Executive Committee to discuss research program direction and progress, research funding, and other matters as appropriate.
2. *Special Meetings.* Special meetings of the Consortium will be called by the President as needed. Committees will meet as required to carry out their responsibilities.
3. *Voting.* Each member institution shall have one vote in the Consortium.
4. *Quorum.* Official or alternate representatives from two-thirds of the member institutions shall constitute a quorum for conducting the business of the Consortium. When a quorum is present, a two-thirds majority of the representatives or their alternates present and voting shall be required for initiation or approval of any action, unless otherwise specified in the Charter.

B. *Research*

The Consortium will:

1. Identify and select specific research problems to be pursued under the Consortium program of Environmental Forestry Studies. It may determine and set the objectives, priorities, and guidelines for studies, based on its interpretation of public need, funds available, capabilities

of institutions and persons, and other work under way within or outside the Consortium.

2. Solicit and entertain proposals for conducting the research from both member institutions and non-member institutions which desire to participate and which have the capability to contribute appropriately to the solution of the research problems selected for study.
3. Evaluate all research proposals submitted to it for which grant funds are requested and select those deemed most appropriate and feasible for contributing to solution of the research problems and priorities it has set.
4. Forward the grant proposals it has selected for Forest Service financing (within the limits of funds expected to be available) to the Director of the Northeastern Forest Experiment Station together with its recommendations, by priorities, for their financing through Forest Service research agreements. Such grants will be subject to usual Forest Service review procedures and legal restrictions.
5. Allocate non-Forest Service funds that may be available. Such funds shall be used to finance additional research proposals, or for other purposes; but the allocation shall be for the purposes intended by the contributor of the funds.
6. Review and evaluate periodically the accomplishments of the research conducted under its aegis.

C. *Information Exchange*

The Consortium will:

1. Arrange for printing and distributing such publications and reports as it deems appropriate. Costs will be shared equally among member institutions unless otherwise unanimously agreed, or paid from Consortium funds that may be available for this purpose.
2. Sponsor seminars, conferences, symposia, and other meetings from time to time to coordinate research in Environmental Forestry, to instruct and educate, and to disseminate results of the research. Costs of such meetings will be

shared equally among Consortium members, unless otherwise unanimously agreed, paid for from Consortium funds, or otherwise discharged as appropriate in each instance. Forest Service contribution to such costs is subject to Federal laws and regulations.

3. Seek to gain public understanding and support for the role of Environmental Forestry and Environmental Forestry Research and their influences through social and ecological relationships in attaining an improved human environment.

ARTICLE VIII.

Adoption and Amendment of Charter and Bylaws

- A. *Adoption of Charter.* The Consortium shall take effect February 1, 1971 and continue until dissolved by a majority vote of its members at the time. Institutions shall become members on the date the Charter is signed below by their authorizing official.
- B. *Charter Amendments.* Each proposed revision or amendment of this charter must be sponsored by at least three members of the

Consortium and submitted to the Executive Committee two months in advance of any Consortium meeting (annual or special) at which the proposal is to be discussed. The Executive Committee will send a copy of the proposal to each member institution at least 30 days in advance of the meeting at which discussion will be held on the proposal, together with notification of the time and place of the meeting. After discussion of the proposal at the meeting, member institutions will vote on the proposal by mail ballot. Approval by two-thirds of the member institutions will be necessary for adoption.

- C. *Bylaws.* As the need arises, Bylaws of the Consortium, and their revisions and amendments, will be developed by the Executive Committee, which will submit them to the official representatives of the member institutions in the Consortium for approval or disapproval. Such Bylaws, revisions, or amendments shall be consistent with the Charter and will become effective 30 days following the date of submission unless one-third of the Consortium members disapprove in writing before that time.
- D. *Signatures.*

Institutional Member

Northeastern Forest Experiment
Station

Forest Service, USDA

Authorizing Official

by: _____
(Name)

(Title)

(Date)

University of New Hampshire
Durham, New Hampshire

by: _____
(Name)

(Title)

(Date)

Massachusetts Agriculture
Experiment Station
Amherst, Massachusetts

by: _____
(Name)

(Title)

(Date)

University of Connecticut
Storrs, Connecticut

by: _____
(Name)

(Title)

(Date)

Yale University
New Haven, Connecticut

by: _____
(Name)

(Title)

(Date)

State University College of
Forestry
Syracuse, New York

by: _____
(Name)

(Title)

(Date)

The Cornell University
Agricultural Experiment
Station
Ithaca, New York

by: _____
(Name)

(Title)

(Date)

Princeton University
Princeton, New Jersey

by: _____
(Name)

(Title)

(Date)

Rutgers University
New Brunswick, New Jersey

by: _____
(Name)

(Title)

(Date)

Pennsylvania State University
University Park,
Pennsylvania

by: _____
(Name)

(Title)

(Date)

APPENDIX II

DEFINITIONS OF TERMS

SERVICES

Human problems are much more complicated today than when man was a hunter-gatherer. The basic problems of survival remain, but they are overlain with a fabric of refinement that creates multiple interrelated problems. These problems are often difficult to perceive in anything approaching totality, whereas single problems were more easily brought into focus. To deal with modern complexity of human existence and focus on understandable entities, society recognizes broadly needed services. These are the vehicle for specifying human problems.

Physical infrastructure.—Those services requiring the creation of physical structures.

1. Water supply and waste disposal: the supply of water for various requirements of man and the disposal of water-borne wastes.
2. Energy: the provision of all forms of utilizable energy in required amounts.
3. Transportation: movement of people, goods, energy, and services.
4. Housing: provision for the shelter of individuals or families.
5. Flood control: the protection of human life and property from flood damage.
6. Recreational facilities: that recreation requiring development. Recreational activities described are part of the social infrastructure, and therefore are included as separate service item number 10.

Social infrastructure.—Those services required by man in his existence in the context of society. While their provision may or may not require physical structures, they are classified in the sense of providing man's social needs.

7. Education: the imparting or acquisition of knowledge, skill, or culture through instruction, training, or study.
8. Employment: the exchange of labor, either physical or mental, for value consideration.
9. Health and welfare: satisfactory conditions of physical and mental health, including

the nourishment, medical supplies and services, and economic requirements of man.

10. Recreational activities: activities for the physical and mental recreation of man.

LOCALES

Locales include any location or place where the services just described are needed or provided. In this system the locale is categorized as follows:

1. Urban: the most heavily developed portion of a city, characterized by high human density, multi-storied buildings, high density of buildings, and scarcity of open space.
2. Suburban: the outlying part of a city or town or adjacent smaller community characterized by moderate human density, single or low-numbered multifamily dwelling, lower building density, and presence of open space around buildings—usually yards.
3. Exurban: those areas around a city, usually beyond the suburbs, characterized by low human density, single-family dwellings, very low building density, and presence of large amounts of open space, often in the form of fields and forests, but not as the dominant landscape character.
4. Rural: those areas that are not part of a city, usually beyond suburbs and exurbs, characterized by low human density, single-family dwellings and outbuildings, with expanses of fields and forests as the dominant landscape character.

DEVELOPMENTS

Man applies his energies in an engineering fashion to produce constructs with which he satisfies his needs for services. We have called these developments. These developments are defined as follows:

1. Heavy industry: that industry that utilizes large amounts of energy and raw material in the more primary stages of raw material conversion, or in the production of large volumes of finished products. These industries

usually cover large acreages and are potentially heavy polluters. Examples include pulp and paper mills, chemical plants, metallurgical plants, and steel plants.

2. Light industry: that industry that is usually labor-intensive and provides secondary or tertiary manufacture. These industries usually cover smaller acreages and are not high-volume polluters. Examples are wholesale and retail outlets, electronics firms, and design and consulting firms.
3. Power: those structures that provide for the direct production (excluding extraction) or conversion of energy. Examples are power dams, power plants, oil refineries, and gas plants.
4. Residences: includes all dwelling places for man—houses, apartments, hotels, and dormitories.
5. Transportation system: includes the structures necessary for transportation of people, goods, and services. Examples are roads, railroads, subways, waterways, sidewalks, pipe lines, power lines, telephone and telegraph lines, and airports.
6. Cultural and institutional structures: includes all structures concerned with development of intellectual and moral faculties by education; provision of facilities for the development or exercise of aesthetic and intellectual appreciation; provision of facilities for man's health and welfare. Examples include schools, churches, hospitals, and museums.
7. Forestry: the husbandry and manipulation of forests. Examples include timber harvesting, timber-stand improvement, tree planting, and habitat manipulation for wildlife.
8. Agriculture: the husbandry and manipulation of nonforested land to produce crops and/or livestock. Examples include farming, dairy farms, sheep grazing, and beef production.

9. Mining: the extraction of minerals (nonrenewable resources) for utilization by man. Examples include oil, gas, coal, gravel, and metallic minerals.

ENVIRONMENTAL EFFECTS

In his efforts to provide needed services in appropriate locales through developments, man often causes changes in various aspects of the environment. The following are environmental effects that may result from any course of action:

1. Air quality: deals primarily with impurities added or deleted from air including gaseous, particulate, and radioactive matter.
2. Water: includes quality, which deals with the addition or deletion of impurities from water, including both organic and inorganic materials and considering temperature and quantity, which in turn deals with flow duration and amount.
3. Soil: the change of one or more soil characteristics such as through addition of effluents, alteration or disturbance by engineering works, or changes in groundwater table level.
4. Temperature and humidity: changes in ambient temperature and humidity. They are considered together because of the magnitude of interdependence. Initial trials indicated that resultant packages were almost identical when temperature and humidity were considered separately.
5. Noise: changes in amount, type, or quality of sound perceived by the human ear.
6. Flora and fauna: changes or effects on plant and/or animal communities. Fauna was combined with flora because fauna is dependent on the habitat provided by flora. Initial trials indicated that the resultant packages were almost identical when flora and fauna were considered separately.

