METHODS FOR OBTAINING AND EVALUATING INPUTS FOR MANAGEMENT INFORMATION SYSTEMS FOR WILDLIFE AGENCIES [2]

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ABSTRACT

The objective of this project was to determine what inputs were being used in decision making in the Division of Wildlife Refuges, Bureau of Sport Fisheries and Wildlife. The problem of identifying information items or inputs for a management information system is not unique to this agency. All resource management agencies must identify input types and specific input items before the agency can develop or use a management information system. A sample list of decisions was identified from publications and reports. A classification system was developed and the decisions were categorized. A method of collecting inputs for decision-making is described that is considered more efficient than the "collect everything" approach. Inputs used to make the decisions showed considerable overlap of use from decision to decision. An objective and analytical approach using a decision matrix was used to determine the relative value of inputs. The relative value of inputs was found to be related to many factors. The study of three factors was reported: the frequency of use of an input, the tendency of input use to clump, and the overlap of use as related to the complexity of decisions.

INTRODUCTION

As demands on wildland resources increase the need becomes critical for better management of existing wildland resources. Better management implies the need for improved decision-making processes linked with a management information system and appropriate controls and checks. Wildland resource management encompasses a wide range of diverse problems and management situations requiring decision-making capabilities equally as responsive as those possessed by large private corporations. Some state and federal wildland resource management agencies are now trying to develop such capabilities to meet the management tasks they face. One such agency is the Division of Wildlife Refuges, Bureau of Sport Fisheries and Wildlife. This paper presents the general basis for decision making and the formal analysis of inputs needed for decision-making in wildland management. The concepts and methods have *general* application; their *particular* use is demonstrated herein for the Refuge System.

A management information system is a basic component of modern, sophisticated management decision-making. A management information system (MIS) is normally a large amount of information stored in a computer and rapidly available for use either in a raw form or as statistics, ratios, or other synthetic relationships. It is a system that can be interrogated to provide useful information. One of the first steps in the development of a MIS is the formulation of objectives for the agency. Objectives or goals are the criteria against which a manager

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can compare the potential consequences of a decision or an action. Without clearly stated objectives, an agency cannot measure its progress or even accurately assess its current managerial capability. It is beyond the scope of this paper to explore the formulation of objectives, but the success of a management information system depends initially on formulation of objectives, and formulation of criteria for evaluating progress toward meeting these objectives. The Division of Wildlife Refuges seems to have made significant progress in this first step in Wildlife Refuges Handbook No. 4, *Objectives*. A second major step in appropriate response to decision-making needs is the analysis of information needs—the inputs to decision-making.

The objective of this project was to determine what information, ideas, facts, and data, hereinafter called "inputs", were being used in decision-making in the Division. Specifically the objective was to supply a sample list of inputs currently being used for decision-making in the Division of Wildlife Refuges. The problem of identifying inputs for a management information system is not unique to the Division of Wildlife Refuges. All resource management agencies must identify input types and specific input items before the agency can develop or use a MIS. Since all wildland resource agencies deal with similar problems and types of decisions, the basic items of information will be very similar in most agencies. Consequently we think identifying inputs for the Division of Wildlife Refuges will benefit a number of wildland-resource management agencies, and will contribute to the future development of information systems for these agencies.

The most obvious method of determining information availability and need relative to decision-making is to identify the decisions or types of decisions to be made by a particular agency. Once decisions are identified, then inputs used in making those decisions can be identified.

DECISIONS

Several possible methods exist for identifying decisions in a resource management agency. First, direct observation of decision-makers during their everyday routine could be used, with an observer recording each decision as it happens. This method has some appeal but the potential returns for the time invested may be low. The probability of identifying very many significant decisions seems to be fairly low. A second method is the questionnaire or "decision-record-keeping-form" approach. This method suffers all the problems inherent to the self-administered questionnaire. A third method, and the one used in this study, is for an outside analyst to identify decisions through judicious inspection of reports, records, communications and publications in consultation with agency personnel. Using this technique it is possible to identify in a short period of time several hundred decisions made at various levels of the Refuge System. A list of 280 decisions was prepared.

These decisions are some subset of a larger population of decisions that are made in the Refuge System. There exists no known method to acquire a statistically sound sample from a population of this type. It is not the intent of the investigator to imply that the 280 decisions used in this study is either the entire population of decisions or a statistically representative sample of that population. An attempt was made to identify a group of decisions that were reasonably representative of the entire spectrum of decisions or types of decisions made in the Refuge System. The absence of statistical control in the sample is not necessarily considered to be critical for the purposes of this study. It is possible that only a few decisions made by any resource management agency are the truly significant decisions, in terms of impact on the resources. It is probable that a large number of the more important decisions have been included in the sample since they are likely to have been identified because of their prominence. Similarly the input items defined for the decisions do not represent all of the input items that would be included in a management information system. However, as most input items are used in many decisions, and considerable overlap of information exists it is probable that many of the input items of major importance are included.

CLASSIFICATION OF DECISIONS

Once a list of decisions made in the Refuge System had been identified, a heirarchial decision classification was developed. The group of 280 decisions was classified by the senior author in consultation with Refuge System personnel using the categories in Table 1. Another classification may be more appropriate for describing decisions made in another agency. Other researchers have utilized different categories in an attempt to describe decisions (*e. g.* Simon, 1960, and Martin, 1965). The U. S. Food and Drug Administration in a decision analysis classified decisions in a functional type of classification (Grant and Coffindaffer, no date). In any list of decisions there are similarities and differences that need to be identified. A classification system or "taxonomy of decisions" is an effective way to deal with this problem. The nature of the System used must effectively reflect the reason for the classification and the use to which the system will be put. No one system of classification is perfect. The "best" classification system is the one that most adequately describes the decisions made in a particular agency for present and future analyses.

TABLE 1. Classification and descriptions used in an analysis of decisions made in The Division of Wildlife Refuges.

Decision Level—Coding and Description

I. SYSTEM FUNCTION: All relevant decisions made within the Refuge System are defined as those directed toward the achievement of Refuge System Objectives. All of these objectives can be classified as primarily directed toward a major system function (viz-a-viz general systems theory) of input, output-objective, process, and feedback. Similarly a decision can be classified on how it fits into the systems framework of the Refuge System Objectives.

Input (1)—Provides inputs to the total system.

Output-Objective (2)—A decision that identifies a desired output or establishes an objective.

Process (3)—The decision is the process by which a stated objective is sought or reached.

Feedback (4)—The decision will provide feedback for the system in evaluating, controlling, or improving System performance or actions.

II. OBJECTIVE: Does the decision have or will it affect single or multiple objectives of the Refuge System?

Single Objective (1)

Multiple Objective (2)

III. FREQUENCY: The frequency with which a particular decision is made.

Frequent (1)—3 or more times/year.

Infrequent (2)—Less than 3 times/year.

Once (3)—The only time this decision has been made.

IV. STRUCTURE: *Unstructured* (1)—A unique decision, no previous experience, has a creative component, may use standard decision techniques but no identical decision is foreseen or has been made.

Structured (2)—More programmed than the unstructured, the operating procedures are more orderly.

Highly-Structured (3)—A decision of a repetitive nature may have been made a number of times previously, solved with standard operating procedures.

V. OCCURRENCE: *Regular Interval* (1)—The interval of occurrence of this decision is predictable and at regular intervals.
Irregular Interval (2)—The interval is not predictable, or if this is the only (first) time this decision appears then the interval is irregular.

VI. INITIAL INFLUENCE: The domain of initial influence. This does not include magnitude of influence or consequence of the decision having been made.
Physical-Biological (1)
Political-Socio-Economic (2)
Both of the Above (3)

VII. LONG-TERM INFLUENCE: The domain of long-term influence. This does not include magnitude of influence or consequence of the decision having been made.
Physical-Biological (1)
Political-Socio-Economic (2)
Both of the Above (3)

VIII. MAGNITUDE OF EFFECT: The impact or magnitude of effect over a reasonable number of years.
An index of importance.
Large (1)—May have a significant effect on the effective management of the System (or refuge if applies only to a refuge).
Small (2)—Negligible effect on the System (or refuge).

IX. LOCATION: Where in the administrative structure of the Refuge System the decision is ultimately made.
Central office, Bureau or above (1)
Regional Director (2)
Regional Refuge Supervisor (3)
Refuge Manager (4)

Analysis of Decisions

Preliminary Analysis of Classified Decisions

Classification of decisions not only provides flexibility in the efficient selection of inputs for decision-making, but provides a mechanism to gain insight into the functioning of a resource agency. Table 2 presents preliminary results from analyzing the frequency of occurrence within the classification system of 280 classified decisions. For example under Level II, 53 of the 280 decisions were classified as contributing to a single objective and the remaining 227 decisions were found to contribute to multiple objectives of the Refuge System.

Hierarchial Analysis of Classified Decisions

The hierarchial structure of the classification levels also lends itself to another analysis. While somewhat peripherial to the task of defining inputs, this analysis can lend further insight to the functional decision relationships in an agency. Such functional relationships reflect chain of command, assigned responsibility, authority to act, personality blocks, and budget control. This type of analysis involves making a hypothesis about what one would expect to find in terms of numbers of decisions falling into various groups, during multilevel pathway searches through the categories. For example; using the last two categories in the decision classification, LOCATION and MAGNITUDE OF EFFECT, suppose a researcher were to explore the relationship between decisions as related to LOCATION or where the decision is made, and the MAGNITUDE OF EFFECT of the decisions. It seems reasonable to hypothesize that "the higher in the administrative level (in the Refuge System), the greater will be the proportion of the decisions made in the large MAGNITUDE OF EFFECT category." Fig. 1 illustrates the pathway search described in this example, the numbers indicate the number of decisions found in each group.

TABLE 2. Preliminary results of an analysis of the frequence and percentage of decisions occurring within categorized decisions.

Level	*Categories*	*Frequency*	*%*
I. System Function	Input	16	5.7
	Output—Objective	13	11.8
	Process	231	82.5
	Feedback	0	...
II. Objective	Single	53	18.9
	Multiple	227	81.1
III. Frequency	Frequent	24	8.6
	Infrequent	113	40.4
	Once	143	51.1
IV. Structure	Unstructured	85	30.4
	Structured	163	58.2
	Highly-Structured	32	11.4
V. Occurrence	Regular Interval	44	15.7
	Irregular Interval	236	84.3
VI. Initial Influence	Physical-Biological	135	48.2
	Political-Socio-Economic	126	45.0
	Both of the Above	19	6.8
VII. Long-term Influence	Physical-Biological	54	19.3
	Political-Socio-Economic	47	16.8
	Both of the Above	179	63.9
VIII. Magnitude of Effect	Large	105	37.5
	Small	175	62.5
IX. Location	Central Office, Bureau or Above	66	23.6
	Regional Director	42	15.0
	Regional Refuge Supervisor	113	40.4
	Refuge Manager	59	21.1

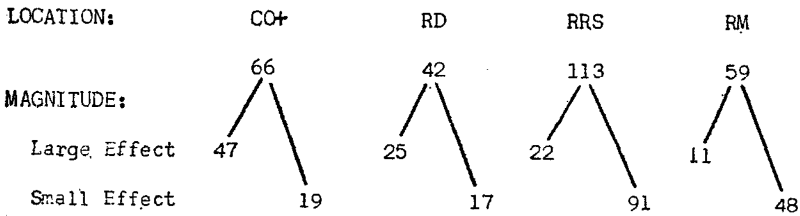

FIG. 1. Multilevel pathway search of two categories in the decision classification.

The previous hypothesis can now be tested against the numbers appearing in the row labeled LARGE EFFECT. Indeed the hypothesis appears to be supported, in that as the administrative level decreases from left to right the numbers of decisions also decrease. However, the converse of the hypothesis, that is "the proportion of small decisions would get larger as the admministrative level gets lower", is not supported by the numbers in the row labeled SMALL EFFECT. It is at this point the administrator can begin to explore the possible implications that may be demonstrated by this type of pathway-search of the classified decisions.

INPUTS

There are several alternative approaches to collecting information for decision-making. The method with which we are most familiar is the typical "shotgun" approach where everything is collected for possible future use. The annual or monthly reports frequently fall into this category. The report consumes considerable time and energy in preparation, but the information is rarely used in making management decisions. Inefficient or non-use of such an information resource is undesirable where improved use is recognized. Increasingly wildland managers must carefully identify what information is needed for management decision-making and then use it, dropping the "nice to know" in favor of the "need to know" type of information.

The method of collection of information for decision-making used in this study made use of the previously identified decisions. From the 280 classified decisions, after eliminating major redundancy, a sample list of 201 decisions was prepared by the senior author. The 201 decisions were divided into 52 sets of 3 to 5 decisions each. The basis for grouping in sets was the classified level in the Division's hierarchy at which the decision would normally be made. Each decision set was distributed to one employee of the Division of Wildlife Refuges with directions to list *specifically* what items of information would be used to make each decision. Fifty-two sets of decisions were originally distributed. After one remailing to non-respondents, a total of 38 (75%) sets were returned.

Of the 201 decisions distributed in sets, 153 (76.5%) were returned. Of the 153 decisions returned, 122 were returned with information considered to be useable for this study. An example of the decisions are presented with their original information items in Table 3. Thirty-one returned decisions were unuseable because the participants discussed *how* a particular decision *is made* instead of listing the *inputs that would be used* to make the decision.

TABLE 3. Examples of decisions and the inputs to each provided by respondents.

TO BUILD A MANAGEMENT ACCESS ROAD

Habitat destruction; alternate access possibilities; construction standards; funding.

TO REMOVE TREES TO CONTROL DISEASE

Information items; effect if trees are not removed; available equipment; cost of operation compared to end result if trees are removed; status of area involved, *i. e.* wilderness area, natural area or management area; complaints from adjacent land owners.

TO ESTABLISH PERMANENT TRANSECTS FOR GAME CENSUS

Information items: Refuge objectives; desired level of accuracy regarding refuge inventory plan; other agencies desiring information; cost of transects compared to data received.

TO PROVIDE FEEDING AREAS

Refuge objectives; type and quantity of feeding area management; political constraints; trade-off of other refuge benefits in order to provide feeding areas; suitability of areas for crops; effects feeding areas would have on other flyway management areas *i. e.* delay of migration, cause overkill on an area, poor quality hunting (fence line shooting).

TO ALLOCATE MORE PUBLIC-USE FUNDS TO A REFUGE NEAR A LARGE URBAN AREA

Does need exist; demand; funds available; plans available for refuge use; capability to develop and maintain.

TO DISALLOW FISHING DURING WATERFOWL NESTING SEASON

Legal constraints of refuge acquisition; refuge objectives; importance of this refuge as nesting area; political pressures; refuge benefits nesting vs. fishing; economic impact on suppliers of fishing services; is fishing compatible with future objectives; will fishing lead to future problems (*i. e.* camping, littering, off-road travel); fishing demand (total use, peak use); manpower trade-off-fishing and/or other programs.

Generally the information items returned by the participants were not as specific as had been anticipated. Part of the discrepancy may have been the fault of the directions. The major problem appeared to be an inability of respondents to articulate inputs as basic quantifiable components of a decision. The specific mode of stating inputs is relatively new, and largely used in fields infrequently associated with wildlife management. The problem can probably be overcome by further instruction or inservice training emphasizing decision-making concepts and techniques. In the directions accompanying each decision set was the statement "if demand is one of the items of information, list *specifically* what the indicators of demand are (*e. g.* demand as indicated by: number of users, number of requests, peak use, etc.)". In general this was not done, and many information items or inputs were presented as rather broad concepts or conglomerates of information. The discrepancy suggests a different concept of what an information item is to a refuge manager (or other personnel) as opposed to an information item to be used in a data base for an information system. Further, this failure emphasizes the difficulty involved in quantifying inputs such as "demand" to be used in the decision-making process. "Demand" is a difficult term to quantify under any circumstances and impossible to use as a decision input unless one has some specific indicators or measures of demand. When a manager says he makes a decision using an information item such as "soil condition" it is evident that he has already aggregated a number of inputs such as pH, top-soil depth, soil moisture, available nitrogen, etc. and labeled them "soil condition".

In order for the returned inputs to be of maximum use in the developing information system, an effort was made, in consultation with Refuge personnel, to interpret the inputs in specific terms. The interpreted inputs or information items thus developed are listed in Table 4 for evaluation on the basis of their potential for contribution to a management information system data base. The data base could serve the Refuge System, or other state or federal wildland resource management agencies.

TABLE 4. List of decision inputs developed from the information items provided by respondents.

1. Probable outputs or benefits (immediate & long range) to be derived.
2. Upper limit of available funds.
3. Compatible with refuge objectives (yes-no).
4. Availability of manpower & equipment.
5. Probability of this activity having large impact on total refuge program.
6. Probability of a favorable reaction from the cooperating agencies.
7. Cost of proposed operation vs: cost of alternatives.
8. Alternatives available.
9. Probability of a favorable reaction from the public.
10. Facilities required.
11. Probable time required for use of funds.
12. Probability of a favorable reaction from pressure groups.
13. Probability that lack of facility/activity is a significant limiting factor.
14. Probability of creating/maintaining high aesthetic value.
15. Probability of ecological/environmental hazards.
16. Probability of a favorable reaction from politicians.
17. Plan and design availability (yes-no).
18. Legal and/or constraints from refuge acquisition.
19. Species to be managed for (plant and/or animal).
20. Probability of continuance as public property (protected).
21. Probability of need for facility or activity in refuge operation.
22. Cost of implementing activity or policy.
23. Past and present land use.

24. Probability of animal management-land management conflict.
25. Probability of benefit to state wildlife program.
26. Distance to nearest equivalent facility or activity.
27. Probability of creating enforcement problems.
28. Probability of an adverse affect on desired species composition.
29. Anticipated animal numbers.
30. Probability of an adverse local economic impact.
31. Number of requests received by year.
32. Probability of geologic hazards (site specific).
33. Projected visits or uses.
34. Projected uses by site.
35. Suitable site(s) available (yes-no).
36. Zone of influence of activity.
37. Probability of hazards to public safety.
38. Does agency have authority to make decision (yes-no).
39. Probability of success as demonstration or education project.
40. Probability of soil construction suitability.
41. Projected maintenance costs of projected facilities.
42. Uses of select sites by year.
43. Special qualifications.
44. Probable rate of increase in use and/or requests.
45. Visits by year.
46. Visits per date by year.
47. Uses of select sites by date by year.
48. Is this a current activity? (yes-no).
49. Ranking of refuge as nesting area (0 to 1).
50. Probability of soil erosion.
51. Projected cost of facility.
52. Probability of a significant increase in production.
53. Probability of improving management techniques.
54. Probability of use of study area by cooperating institutions.
55. Probability of developing regional capabilities.
56. Access to site(s) available (yes-no).
57. Probability of developing access to site(s).
58. Soil conditions; pH, top soil depth, moisture, nitrogen availability, deficiencies.
59. Availability of construction materials.
60. Cropping seasons.
61. Probability of creating conditions conducive to overharvesting.
62. Probability of overutilization of vegetation by animal species.
63. Contractural requirements and provisions.
64. Probability of significant wildlife habitat loss or damage.
65. Probability that current facility or activity is surplus to needs.
66. Probability of creating off-refuge crop depredation.
67. Cost of administrative and "cooperative" activities.
68. Minimum staffing costs.
69. Total number of users (site specific) allowed by policy decision.
70. Zone of influence of site(s) (radius in feet).
71. Presence & numbers of plant species indicating disturbance.
72. Probability of soil percolation suitability.
73. Probable availability of water for area maintenance.
74. Probability of loss due to vandalism.
75. Probability of animal disease problems.
76. Political probability of agency recognition for useful application of information.
77. Probability of the establishment or increase of undesirable vegetation.
78. Age structure of visitors.
79. Probability of high demand for commercial product (timber, oil, etc.)
80. Probable availability of water for users.
81. Average length of stay of user.

82. Projected maintenance costs of present facilities.
83. Information required by Central or Regional office (yes-no).
84. Probability of problem reoccurrence.
85. Water requirements by date.
86. Probability of creating shortstopping.
87. Other agencies desiring information (number).
88. Hydrologic or water fluctuation data.
89. Size of area under consideration.
90. Probability of demand for continuity in data.
91. Cost of getting information.
92. Proportion of information most likely useful.
93. Probability that present structures or facilities are adequate.
94. Anticipated precipitation.
95. Probability of wildlife loss.
96. Status of water and flowage rights for area concerned.
97. Probability of benefits of refuge owning equipment or facility vs. rental or contract.
98. Would user activity be wildlife oriented (yes-no).
99. Ratio of open to forested land.
100. Number of refuge entrance points.
101. Availability and source of water.
102. Probable information available and deliverable.
103. Required or desired level of accuracy in sampling.
104. Estimated carrying capacity by species by season.
105. Natural environmental limiting factors.
106. Flyway or Regional priorities.
107. Probable interval between successive samplings.
108. Ratio of wetlands to forested land.
109. State water law constraints.
110. Ability of a refuge to meet objectives.
111. Status of species (common/rare/endangered, etc.).
112. Zone of influence of road(s) (radius in feet).
113. Refuge personnel housing available (yes or no).
114. Evapotranspiration rates.
115. Probability of increased salinity.
116. Litter deposit rate.
117. Harvest distribution from past banding (or records).
118. Land capabilities to provide natural feed (K cal.) by refuge.
119. Probability of a significant increase in predation.
120. Probability of damaging a resource through flooding.
121. Intensity of competition for existing nesting sites (0 to 1).
122. Average income of local user.
123. Sex and age of animals.
124. Significance of introduction of pest fish species.
125. Number of violations per year.
126. 1000's of copies of publication issued by year.
127. Publication costs.
128. Prevailing wind direction and velocity.
129. Predicted energy needs (in K cal.) by area.
130. Number of personal letters written about topic potentially covered by a publication.
131. Average cost of researching and writing the personal letter.
132. Local pesticide recommendations and regulations.
133. Probability that required skills are available.
134. Demand for animals by other agencies.

In place of the self-administered questionnaires (as used in this study) the personal interview seems to have merit as an alternative method of identifying inputs. The interviews would likely prevent the need for secondary interpretation of information items.

Information Overlap

Overlap in information refers to the use of an input in several decisions. It is necessary to explore the significance of overlap in information, in order to begin to determine the value of a particular item of information for decision-making. One way to get a feel for the magnitude of information overlap is by relating decisions and inputs numerically as in Tables 5 and 6. Table 5 shows that the frequency of occurrence or use in decisions of particular input items ranged from a high of 119 (*i.e.*, item No. 46 was used in 119 decisions), to a low of one (item No. 134 was used in only one decision). Conversely, Table 6 shows that the number of different inputs required in a particular decision ranged from a high of 63 (*i. e.*, decision No. 83 required 63 distinct items of input) to a low of nine (decision No. 17 required only nine items of input).

TABLE 5. Use of individual inputs listed in decreasing frequency of use.

Item Identification Number	*Number of Decisions Using this Item*	*% of Decisions Using this Item*
46	119	97.5
...	...	...
...	...	...
51	112	91.8
...	...	...
...	...	...
70	57	46.7
...	...	...
...	...	...
77	21	17.2
...	...	...
...	...	...
122	5	4.1
...	...	...
...	...	...
134	1	0.8

TABLE 6. Numbers of inputs required by various decisions.

Decision Number	*Number of Different Inputs Required to Make this Decision*	*% of All Inputs Required*
83	63	51.6
...	...	...
...	...	...
148	57	46.7
...	...	...
...	...	...
138	50	40.9
...	...	...
...	...	...
13	38	31.1
...	...	...
...	...	...
17	9	7.3

Determining Relative Value of Inputs

When decisions are classified, differences evidently exist between decisions. Similarly, it is reasonable to expect differences in inputs, particularly differences in the relative value of inputs. All wildlife resource management agencies are constrained in the inputs that they can obtain by the size of the agency's budget. Generally there won't be adequate funds available to collect all of the desired inputs for decision-making. Consequently in order to make decisions most effectively, an agency must try to determine the relative value of inputs and then collect those inputs that are most valuable in terms of decision-making, or those inputs that provide the greatest decision-making capabilities per dollar spent. Overlap in the use of information items tends to mask and complicate the determination of the value of inputs. For example an information item is probably worth more in some decisions than in others, so not only do different items have different relative values but the value of one particular item is probably not constant from decision to decision.

Subjective Ranking Technique

Several potential methods exist for exploring the relative value of information items. One technique which has been applied in similar valuation problems is the "subjective-ranking technique". The subjective-ranking technique requires that a person or group of persons experienced in making a particular type of decision rank in order-of-importance a group of inputs used in making a particular decision. An easy way to use this technique is to ask the question; "if you will agree that this list constitutes the inputs you would use (or would like to use) to make this particular decision and you cannot afford to have all the items, which is the first, second, etc., that you would be willing to give up?" In this manner it is possible to rank each input used in each decision, assigning a proportionate index of importance from 0 to 1.0 to each input in the group. By averaging the indices for an input over all decisions an index of importance is obtained for a particular input. Table 7 illustrates an example of obtaining subjective values for a few input items. The results indicate that input item number 51 is more valuable in decision-making than item number 9, however, the index does *not* indicate how *much* more important, only that it is relatively *more* important.

TABLE 7. Illustration of the subjective-ranking technique for determining the relative value of information items.

Input Ident. Number	*Decision Ident. Number* 12	43	16	*Subjective Value Index*
9	0.3*	0.1	0.2	0.2
51	0.5	0.3	0.4	0.4
68	0.6	0.1	**	0.3
. .	etc.	etc.	etc.	

* Numbers in the body of the table indicate the value index for that input in that particular decision.
** A blank indicates item #68 was not used in decision #16.

There are several deficiencies inherent in the subject-ranking approach. One is simply the mechanics of getting decision makers to provide the time necessary to rank the inputs. A second and more serious problem exists in being able to get consistent ranking of inputs. The problem may partially be alleviated by using a group consensus in ranking or averaging entries from a group.

Objective-Analytical Techniques

The method used in this study to explore the significance of overlap in information and the subsequent relative values of information items is an objective and analytical approach. This is a potentially more powerful method than the subjective-ranking approach in that it allows quantification in the determination of values. The technique of this approach is to explore the relationships between decisions and input frequencies through a table called a *decision matrix*. Table 8 illustrates a hypothetical *sorted decision matrix*, in which the information items are listed (decreasing left to right) by frequency of use. Decisions are listed (decreasing top to bottom) by the number of inputs required. The large size of the decision matrix for the Refuge System analysis (122 decisions by 134 inputs) required the use of a digital computer to explore the relationships between the inputs and decisions.

TABLE 8. An hypothetical decision matrix demonstrating frequency of use of inputs in decisions. A 122 by 134 matrix was developed for the Refuge System.

		INPUTS (Decreasing frequency of use →)					
		46	28	51	43	75	Total
	83	1	1	1	1	1	63
DECISIONS	196	1	1	1	1	0	63
(Decreasing number	15	1	1	1	0	1	61
of inputs required	88	1	1	0	0	0	..
per decision)	173	1	0	0	0	0	..
	Total	119					
	%	97.54					

Frequency Analysis

One of the simplest ways to use the matrix is by inspecting the frequency of use of information items in decision-making. A preliminary simplifying assumption for analysis was made that all inputs have equal cost and all decisions are of equal importance. A first, and conceptually the most simple valuation was made that the higher the frequency of use, the higher the value of the input. For example, the percentage row at the bottom of Table 8 indicates that item number 46 is used in 119 decisions or 97.54% of the sample of decisions. Another way to interpret this is that the probability that input number 46 will be used in decision-making is .9754, where certainty equals 1.0. The major weakness in the example just discussed is the over-restrictive assumptions that inputs have equal costs and that decisions are equally important. It is at this point that the previously described decision classification begins to provide additional support for the evaluation of inputs. Within the classification system, the category MAGNITUDE OF EFFECT provides another index of importance for each decision. The previously described "number of inputs" and thus complexity is another such index. If the 119 decisions in which item No. 46 is used were searched for those with a LARGE MAGNITUDE OF EFFECT, it is possible that none of the 119 decisions in which item No. 46 is used have a LARGE EFFECT. Consequently, in terms of making decisions of LARGE EFFECT item No. 46 would be insignificant in a decision-making system.

Within any resource agency the funds probably won't be available to develop an information system to provide inputs to all types of decisions. The inputs required and decisions made by a refuge manager or game biologist are different from those inputs required by a state or regional supervisor. Priorities must be established within an agency on the type of decision system for which inputs will be provided. Once priorities are established, the classification system provides the flexibility to select the criteria for selecting those inputs to be included within an information system. In this way it is possible to tailor an information system or several subsystems to the needs of a particular wildlife agency.

Grouping Analysis

From gross inspection of the decision matrix it appears that some relationship exists between inputs that causes them to be used together in a number of decisions. An analysis of the Refuge System decision matrix indicated the following type of relationships: Item No. 46 is used in 97.5% of the decisions while item No. 28 is used in 91.8% of the decisions and they are used together in 89.3% of the decisions. Item No. 51 is also used in 91.8% of the decisions but it and item No. 28 are used together in 86% of the decisions.

When combinations of items used together included groups of 1, 2, 3 . . . etc. were generated (beginning with the most frequently used items), relationships of the following type were indicated. The six most frequently used items were all used (together) in over 70% of the decisions. The 10 most frequently used items were all used (together) in 44% of the decisions. Relationships like the above need to be considered in selecting items to be included in an information system. If items show strong "clumping" tendencies, the removal of certain items could reduce the effectiveness of the remaining items for decision-making.

Needs Analysis

A third way to use the decision matrix might be in response to the question: "how many (or which) inputs do I need in order to make 50% of the decisions in the sample?" First, in order to answer this question, it must be known which 50% of the decisions are to be made. Again, the decision classification system provides the criteria for picking out which 50% of the decisions are desired. Another criterion might be the 50% of the decisions that are the most complex decisions. Under this criterion the assumption might be made that the number of inputs required to make a decision is an index to the complexity of a decision. Using this assumption the analyst could simply determine how many (and what) inputs were required to make that half of the decisions. Disregarding which 50% of the decisions are to be made, how many inputs are required to make 50% of the 122 decisions in the Refuge decision matrix? This is approached by adding inputs into a group (called a solution) until enough inputs are obtained to make 50% of the decisions. Obviously the number of inputs required to make 50% (any 50%) of the 122 decisions depends on the order in which the inputs are brought into solution (added to the group).

Fig. 2 illustrates four cumulative frequencies generated by bringing inputs into the solution in four different orders. Each curve represents the cumulative number of decisions that can be made with each new input added to the system. Curve 1 in Fig. 2 represents the cumulative decisions made as inputs enter the solution with the most frequently used input entering first, adding inputs in order of decreasing frequency of use. Curve 4 represents the cumulative decisions made by entering the least used input first, adding inputs in order of increasing frequency of use. In curve 4 the most used input is added last. Curves 2 and 3 were generated by adding inputs into the solution at random without reference to the frequency of use of the inputs.

If the objective is to develop an information system or group of inputs that would make the most decisions with the least items of input, curve 4 represents the worst solution. The curve represents the results of collecting inputs that would produce the fewest decisions for a maximum number of inputs. On the other hand, curve 1 represents the best solution. In general, throughout most of its range curve 1 represents the order of accumulating inputs that would allow the most decisions to be made with a minimum number of inputs. Curves 2 and 3 represent the extremes of bringing inputs into a system in a random order. When all four curves are considered, it becomes obvious that the order in which inputs are added to a system is very important for maximizing the number of decisions made with a minimum number of inputs. Curves 2 and 3 indicate that although it is possible to construct a fairly efficient system (curve 2) it is equally possible to construct a very poor system (curve 3). In answer to the earlier question, Fig. 2 indicates it requires approximately 105 (78.3%) of the inputs to make 50% of the decisions.

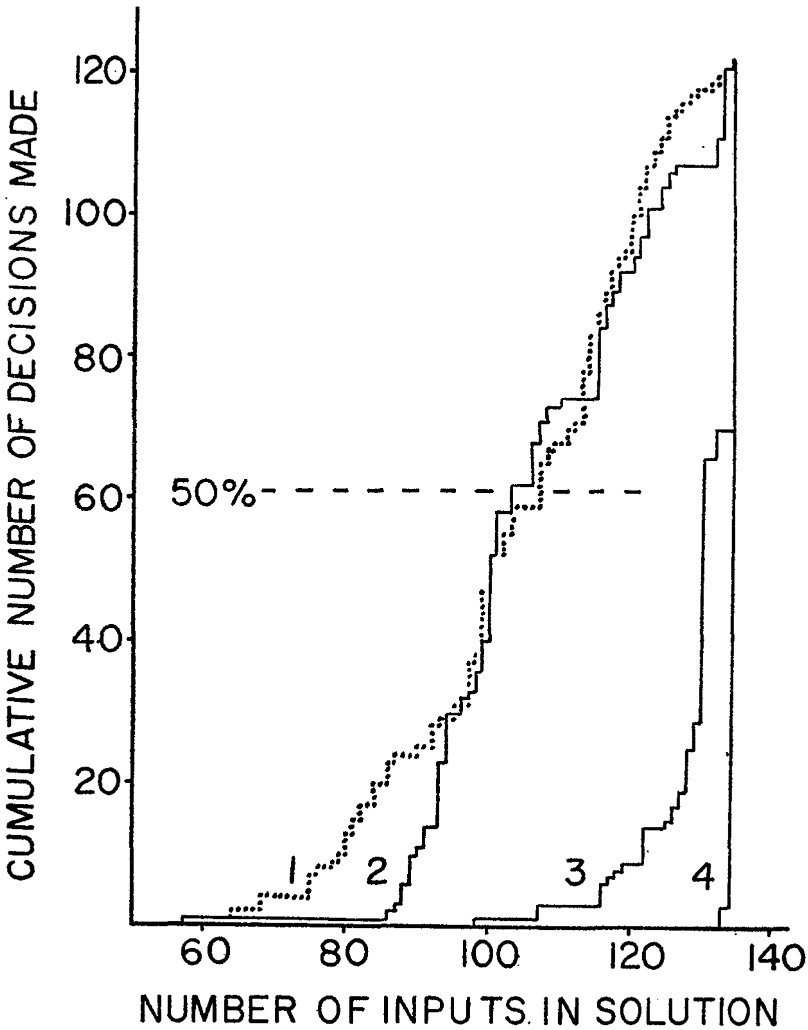

FIG. 2. Number of inputs required to make decisions in a large decision system. Where (1) most frequently used inputs are entered first, (2 and 3) inputs are entered at random, and (4) inputs are entered in the order of least used being entered first.

CONCLUSIONS

One approach for defining information availability and needs for a wildlife management agency is through identifying and describing decisions made by the agency. The method considered most appropriate for identifying decisions was through inspection of reports, records, and publications. Once decisions are identified and described with an appropriate classification system, the functional decision-making of an agency can be investigated. The appropriate classification system is the one that describes the decisions made in a particular agency in a way that can be used to obtain ranked inputs. A hierarchial structure of classification increases the flexibility and potentials for later analyses.

The method of collecting decision-making inputs developed in this study is considered to be more efficient than the usual "shotgun" approach, where everything possible is collected. If decision-making information were collected via personal interviews the need for secondary interpretation might be eliminated.

Knowledge of the relative value of inputs is important for improving the cost-effectiveness of decision-making. In order to make decisions most effectively, an agency must try to determine the relative value of inputs and then collect those inputs that provide the greatest increases in decision-making power and reduction in risks per dollar. Overlap in the use of information for decision-making tends to complicate the determination of the value of particular inputs. An objective and analytical approach using a decision matrix to determine the value of information items is a more powerful approach than the subjective-ranking approach. Relative value of inputs is related to many factors. The study of three such factors has been reported: the frequency of use of an input, the tendencies of input use to clump, and the overlap of use in inputs particularly as related to the order of complexity of decisions and the sequence with which use-frequency ranked inputs are added to the information system. Continuing studies of the matrix will enable the development of an information system that is optimum for wildland agency decision-making needs.

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