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9. ABSTRACT
A series of theoretical models of how decisionmakers design and administer natural resource information projects were established. The author then conducted field work in Guatemala, Costa Rica, and Colombia, during which he attempted to relate the theoretical models to the actual decisionmaking performed by real-world administrators (25 decisionmakers in six case studies). The field work demonstrated that the theoretical models were of no practical use whatsoever. Then, in a move that transcended the frequent dissertation exercises in unrealities, the author rather carefully analyzed why the theoretical models, and the literature upon which they were based, had very little to do with the real-world behavior of the administrators whose decisions the models were supposed to simulate and explain. A first obstacle to use of the models was that they were based on the assumption that administrators make rational choices concerning what information to gather, and then base resource allocations upon decisions reached after evaluation of the information obtained. In reality, says the author, the reserve is true; the decisions are not made solely on the basis of achieving the ostensible goals of the organization. Maintenance and growth of the organization are evidently organizational goals in and of themselves. These may or may not have much to do with the stated goals of the organization (and the information needs related to those stated goals). A third obstacle relates to a lack of tradeoffs between multiple goals. The theoretical models assumed that organizational goals had been well defined, and that tradeoffs between multiple goals were well understood. A fourth obstacle concerns the fact that often information activities are carried out habitually, as a matter of course, with no conscious consideration of why they are conducted by the organization. A fifth obstacle is the requirement for a consistent and explicit expression of risk aversion. Several

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other rather technical obstacles are discussed. The author concludes that no quantitative model can optimize the design of information projects in real-world situations, but this does not mean that one should dismiss the theoretical base upon which such a model would rest. Understanding of that theory will focus attention on designing information projects well.

THE ECONOMICS OF FORESTRY INFORMATION: CASE STUDIES IN CENTRAL AMERICA

A THESIS

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL

OF THE UNIVERSITY OF MINNESOTA

by

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For the described situation, however, the validity of the theory appears to remain sound. Several guidelines for the design of such information projects which emerged from the research are presented.

Approves Hans A Gregersen Oct 15, 1975
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Robert Patric Latham
187 words

Abstract

THE ECONOMICS OF FORESTRY INFORMATION:
CASE STUDIES IN CENTRAL AMERICA

The study reported is an analysis of the design of natural resource information projects. A series of theoretical models were developed which attempt to identify and relate the major factors considered in the design of such projects. The factors include: (1) state of current knowledge about relevant variables, (2) impact of errors in estimating relevant variables, and (3) costs of reducing the errors on the relevant variables. Theoretical methods of relating these factors and of both determining optimum budgets for information gathering and of internally allocating such budgets are presented. A computer program was developed which computes optimum budgets and allocations for very simple situations.

A series of case studies carried out in Central America tested the validity and practical use of the theoretical models. Six information projects were analyzed through iterative interviews. A variety of obstacles were identified which preclude the practical application of the theoretical models.

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PREFACE

The production of information consumes scarce resources. By definition, therefore, it is an economic process and should be subject to economic rationale in its management. Within the broad world in which we live, there is an infinite variety of subjects about which we could produce information. Given the apparently insatiable human thirst for knowledge, each of these subjects could be investigated virtually to infinity. But how do--and should-- we make decisions about what to investigate and in what depth? That question, in itself, is worthy of investigating.

This paper will treat some limited aspects of that question. Since the author is a forester and the research reported herein was conducted largely in Latin America, the specific treatment will be limited to

those areas. It is hoped, however, that what is said will be relevant to a wide range of natural resource management in less developed countries (LDC's) and, in some respects, to all information projects.

The research reported in this paper was sponsored in part by a grant to the University of Minnesota Economic Development Center from the U.S. Agency for International Development. The conclusions reached, however, are solely those of the writer and do not necessarily reflect the position of U.S. AID.

Chapter I
INTRODUCTION

Since information generation is an economic activity, then the management and evaluation of those projects which generate information should take cognizance of available economic guidelines. The primary focus of this study will be on those projects which have, as their major purpose, the generation of information. Projects are here defined to be identifiable collections of activities carried on by an identifiable person or group of persons and subject to some identifiable control. Those projects which have other purposes, but which incidentally produce significant amounts of information, are also of interest but are not the major focus. The interest is also limited to goal-oriented, management information and does not consider, directly, the more open-ended, pure research projects.

The entity of interest, therefore, may range from a major resource inventory project to a single individual's activities within a directly productive enterprise. The distinguishing characteristic is that identifiable decisions have been made which determine what kind and how much information will be produced.

The author's ultimate objective is to make what small contribution to economic development as he may be capable of. It is assumed that increased (or more rational) utilization of natural resources will provide significant, long-run improvements for that vast majority of the human race which lives in the less-developed world. The current debate regarding the appropriateness of an objective of long-run economic growth will not be treated.

Whether forest resources, in particular, can make a significant contribution to economic development or not is subject to some debate. Westoby (1962), in a classic article, as well as others (Sartorius and Henle, 1968; Herfindahl, 1969) provide a wide range of reasons why forest resources are especially useful in the attack on underdevelopment. In numerous specific examples, however, the promised contribution of the forestry sector has fallen short of expectations. For the purposes of this study, no more is assumed than that an increased and more rational utilization of the

forest resources in any LDC will provide positive benefits. No more justification should be needed.

Within the general context of resource development, and more specifically in forest resource development, questions may arise concerning the need for study of the design and management of information projects. It is asserted that a large portion of the vital resources which are devoted to information projects in LDC's is essentially wasted. The bookshelves of agencies and companies throughout the less-developed world are filled with dust-covered reports which are not, and cannot be, used to guide resource development. The meager tax revenues available, the sharply limited foreign exchange, and critically scarce technicians are often devoted to information projects which, in the final analysis, yield no change.

Numerous examples can be cited in which major--and very costly--information generation projects have been completed and of which very little use has been made. For example, a multi-million dollar forest inventory has been completed for large sections of the Amazon Valley and has not proved too valuable from an economic development standpoint. Indeed, the major expert on the project has suggested that no further work of this type be carried out (Heinsdijk, 1965). Similar examples of smaller and more mundane projects

are even more plentiful. Even in those projects which do produce valid and useful information, substantial questions can be raised concerning the efficiency with which the information was produced.

In the future, it is probable that there will be an increasing demand for increasingly precise resources information. As McKelvey (1972) so cogently points out, resource policy controversies which loom in the future will induce demands for accurate information, whether that information would be helpful in resolving the policy questions or not.

The purpose of this research project is to ascertain what principles of design and management of information projects are useful in avoiding some of the pitfalls noted above and which might provide more efficient use of the inputs expended in the generation of information. The following questions were to be explored:

(1) Is it possible to build meaningful theoretical models which would predict optimum designs for information projects such as those described above?

(2) Are the basic assumptions which go into such models valid in real-life projects? If not, what assumptions are valid?

(3) What methods are used in real-life information projects to determine overall funding levels and

how are the funds internally allocated?

(4) How do these actual methods compare with the theoretical models?

If general principles for the design of such information projects exist and can be discovered, they should have certain implications for information policy for LDC's. An attempt will be made to spell out any which seem evident from the research.

The method of presentation will consist of a report of the research carried out and what the author believes its implications are for the design of information programs. The theoretical models which were initially developed are first presented followed by the description of a hypothetical game which was developed. The methodology for field studies and their results are then shown. A discussion of the overall results and the conclusions drawn therefrom complete the dissertation.

The first conclusion, and the one in which the writer has the greatest confidence, is that this is a subject of enormous proportions which has tentacles running into every aspect of natural resource management. He began the study with some degree of naivete and a large faith in the ultimate rationality of man. Some measure of both have been lost.

Chapter II

SOME THEORETICAL MODELS

The purpose of this chapter is to lay out the design theory which was initially developed for this study.

These theoretical models purport to given an economically optimum method for determining the amount that decisionmakers should invest in information projects and how this total amount should be divided between multiple variables being investigated. The models which are presented here have now been subjected to field testing, and certain aspects of them are now viewed in a somewhat different light.

An introductory note is appropriate here. Some of the models appear very mathematical. It would be futile as well as false for the writer to claim any

virtuosity in statistics or mathematics. Nonetheless, the language of those fields provides a very concise method of transmitting ideas. That language has been used, not in any attempt to contribute meaningfully to those fields, but for efficiency reasons only. It is hoped that this use does not do too much violence to the sensibilities of those fields.

In order to understand the decisionmaking involved in the design and management of information projects, it is necessary to understand the decision scheme of the more fundamental program of which the information project is a part. That implies, of course, that information is never produced for its own sake but only to supply the needs of more basic resource allocation decisions. That assumption will be discussed in some depth below. At the moment, however it will be necessary to describe this overall decision scheme and extract from it that small but significant part which will be of interest.

After the part of interest has been defined, the detailed theoretical models will be presented. These models, which provide an economic rationale for funding of information projects and for the internal allocation of these funds, will be detailed in the same manner in which they were developed. That is, the first ones presented will rely on a series of assump-

tions which reduce the complexity to manageable terms. Then these assumptions will be progressively relaxed until the final models, hopefully, correspond to the real world.

The Overall Decision Scheme

One can envision a decisionmaker who has certain objectives, certain policies and a certain perception of how well these policies achieve his objectives. If he perceives a significant divergence between the results of his current policy and his objectives, or perhaps someone external to the organization perceives a divergence between what he thinks the objectives of the organization are and what current results are, then some proposals for changes in the policies are elicited. We will assume for the moment that these proposals arrive directly from Heaven or from some economics professor. Now the decisionmaker must appraise the proposals and decide which one to choose (or to opt for the status quo). Then he will implement and monitor the policy selected. The appraisal portion of the framework is our subject of interest. For those who find it useful, including the author, the sequence is shown diagrammatically in Figure 1 with the appraisal portion expanded.

In the appraisal process the decisionmaker will,

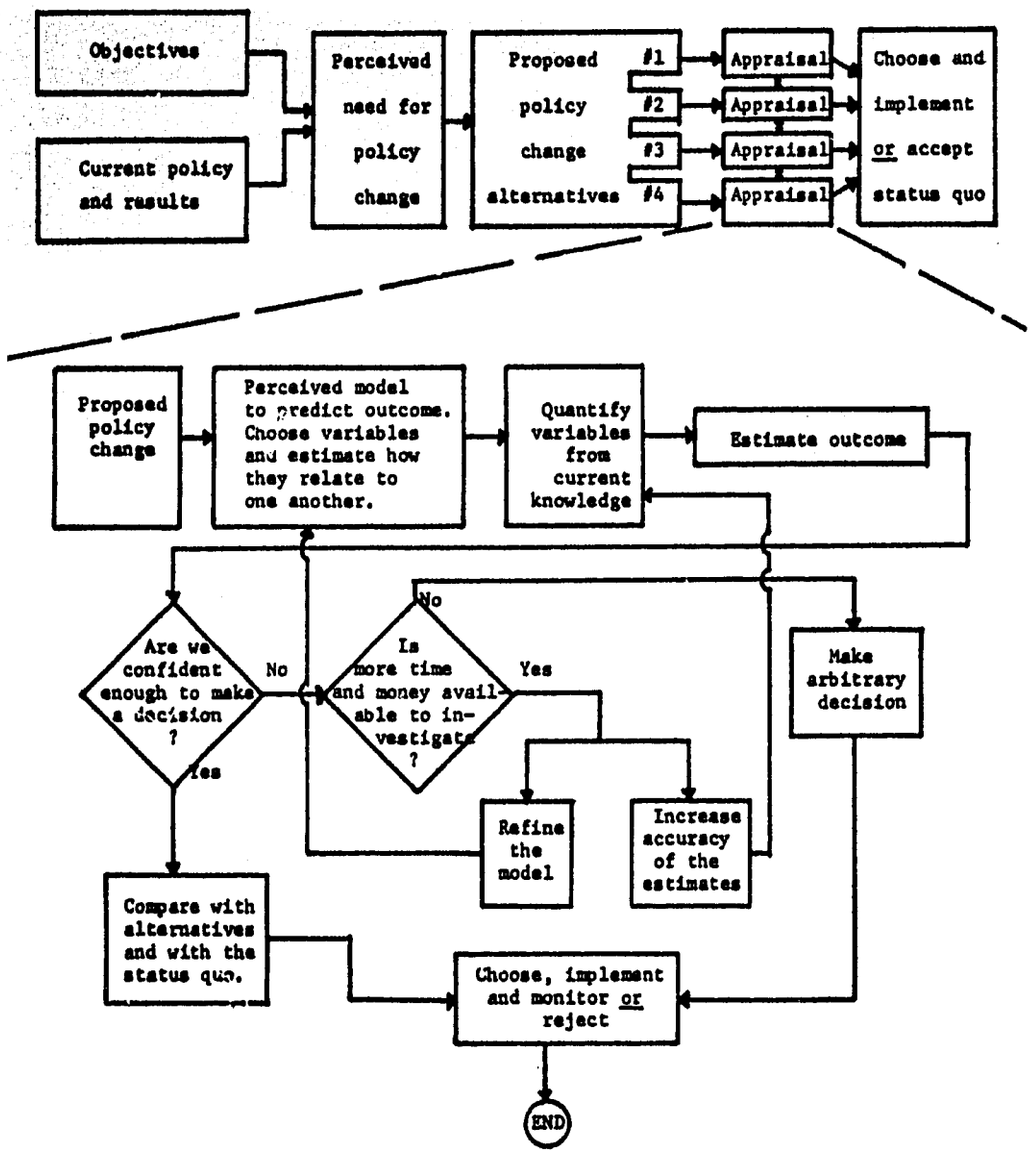
Objectives
Current policy and results
Perceived need for policy change
Proposed policy change alternatives
#1
#2
#3
#4
Appraisal
Appraisal
Appraisal
Appraisal
Choose and implement or accept status quo
Proposed policy change
Perceived model to predict outcome. Choose variables and estimate how they relate to one another.
Quantify variables from current knowledge
Estimate outcome
Are we confident enough to make a decision ?
No
Yes
Is more time and money available to investigate ?
No
Yes
Make arbitrary decision
Refine the model
Increase accuracy of the estimates
Compare with alternatives and with the status quo.
Choose, implement and monitor or reject
END

Figure 1

implicitly or explicitly, build a model to predict the outcome of each proposal. The models will include the necessary inputs, the transformation functions and the predicted outputs. Using this model and his current state of knowledge, he will predict the outcome of the several proposals and, if it is possible, a choice will be made. If so, no further investigation is needed. The decision is made, implemented and monitored. Of course, it would be unfashionable to leave out a feedback cycle in such a diagram.

Alternatively, the decisionmaker may not have sufficient confidence in his predicted outcomes to make a choice. If such is the case, we presume that he will devote some resources at his disposal in the process of investigation. He will methodically lay out the predictive models, fund an investigative process, allocate that budget wisely in information generation, and with his new state of knowledge, go through the appraisal process again. This continues until a decision is made. How he "...funds an investigative process, and allocates the budget wisely..." are the subjects of interest.

The reader will notice how slyly we have avoided the question of how the decisionmaker chooses between the several alternative proposals. That is a subject worthy of a great deal of study (see, for example, Van

As, 1967) but is not the subject of the present enquiry. Some fairly standard assumptions will be made and no further discussion will be provided.

The Productive Process Model

If a decision such as those outlined above is needed--say a plant location decision by a private firm or a decision concerning a major concession by a public agency--the decisionmaker must, implicitly or explicitly, have a model of the productive process about which the decision is being made. This model, hopefully of an explicit nature, would relate the various productive inputs to the objectives of the organizations. The magnitude of these various productive inputs and outputs are uncertain to the decisionmaker and are therefore the subjects of the investigation procedure.

A simplified example is perhaps useful. Let us assume that a private firm is engaged in the sawmilling business and is contemplating locating a sawmill in Town X. Its objectives are maximum profitability and it knows that this profitability depends on the quantities and prices of its outputs and the quantities and costs of the various inputs over the several years of the investment. Let us further assume that there is a fairly well established technology for any sawmill

appropriate for Town X and the inputs and outputs are fairly well known. Therefore, the decisionmaker's model might be something like:

$$Y_{BE} = \frac{Q_1 P_1 + Q_2 P_2 - (Q_3 P_3 + Q_4 P_4 + Q_5 P_5)}{(1 + r)} + \frac{Q_1 P_1 + Q_2 P_2 - (Q_3 P_3 + Q_4 P_4 + Q_5 P_5)}{(1 + r)^2} + \ldots + \frac{Q_1 P_1 + Q_2 P_2 - (Q_3 P_3 + Q_4 P_4 + Q_5 P_5)}{(1 + r)^n} \quad (1)$$

Where:

Y_{BE} = Best estimate (maximum liklihood) of present value of net returns in current dollars.

n = Years of life of the investment.

r = Discount rate.*

Q_i = Quantities of the various inputs and outputs.

P_i = Prices paid and received for the various inputs and outputs.

It can be argued, of course, that it is not nec-

* Selection of an appropriate interest rate is problematic and can have a heavy impact on design procedures (see, for example, Herfindahl, 1969, p. 98 ff.). Interest rates are so pervasive and have been treated in such depth elsewhere (e.g. Arrow, 1966) that they will not be discussed further here.

essary to postulate a profit-maximizing firm. Such models should be equally applicable to public agencies which seek to maximize net social welfare. The operational usefulness of that is quite another question, however, and will be discussed below.

It is asserted that any decisions that are made concerning the investigation process (which are preliminary to a decision about the investment) must have such a model elaborated if the investigation process is to be managed well. As will be seen below, these models of the productive process are essential to the information program models.

The Information Models

Now we have come to our major area of interest--the analysis of the information generating activities which will provide a basis for the decisions previously discussed. Two major aspects must be treated in analyzing information activities such as these. First, for any given information budget, it must be allocated between the several variables to be studied in order to obtain the maximum value of information possible. Secondly, given this optimum internal allocation for several different sizes of total budget, the appropriate budget size must be selected.

It should be noted at the outset that these mod-

els involve application of standard marginal analysis to the design of rational information programs. Given some state of knowledge at a moment in time, they indicate that X amount of money should be spent on information gathering and it should be internally allocated according to these rules. The models are based on a priori estimates of information production functions. Whether they are successful in actually predicting what one will learn during the information gathering process is quite another problem and is not the subject of this study. All they do is provide a formal means of incorporating our current knowledge into a rational plan for gathering more knowledge.

The first of the information models will attempt to provide a rationale for determining the size of budget for information gathering. We must begin with our productive process model which was (ignoring for the moment the discounting needed and eliminating the sign change by using negative prices for costs):

$$Y_{BE} = Q_1 P_1 + Q_2 P_2 + Q_3 P_3 + Q_4 P_4 \ldots Q_n P_n \qquad (2)$$

Where:

Y_{BE} = The best estimate of profitability

Q_i = Quantities of inputs and outputs

P_i = Average prices received (positive) and costs paid (negative) for inputs and outputs

Now let us define:

$$Y_{ME} = Y_{BE} - \left\{ t_{1-\alpha} \sqrt{V(Y)} \right\} \tag{3}$$

Where:

Y_{ME} = Minimum expected profitability (or lower confidence limit at $1-\alpha$)

t = Standard normal deviate for $1-\alpha$ level

$V(Y)$ = Variance of current best estimate of profitability

The quantity Y_{ME} is central to the model and requires some explanation. If we are given the productive process model and we have some estimate of the variables therein plus some ideas about variability of these estimates, then we can, through some standard aggregation techniques*, develop a probability distribution for the expected value of profitability or $E(Y_{BE})$. Such a probability distribution might look like that in Figure 2.

*For one such aggregation technique see Cochran (1963, p. 89 ff.

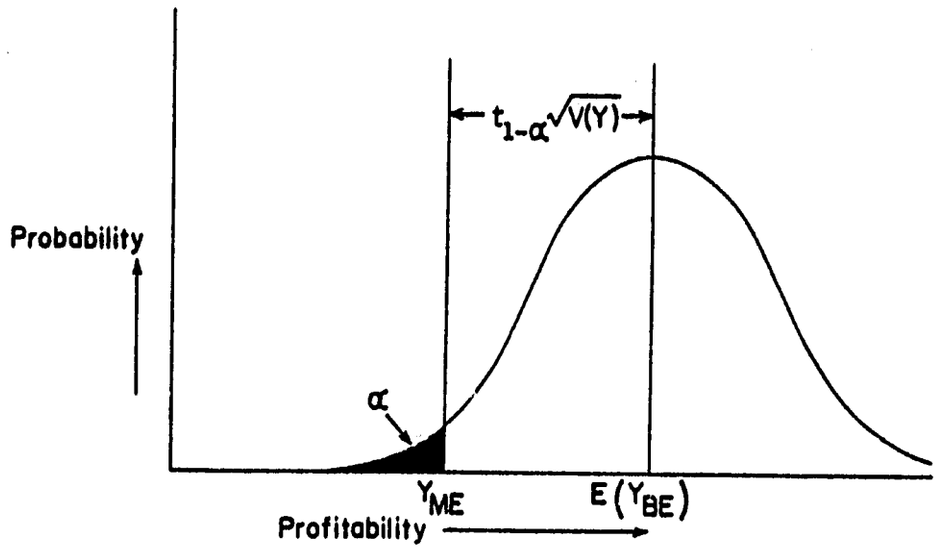

Figure 2

Now let us go back to the basic decision model. If this decision is one which will have a large impact on the overall performance of the organization and one in which the decisionmaker has a great deal of uncertainty, then the decisionmaker will not be totally concerned about the best estimate of profitability. He will, instead, be more concerned about some lower limit which he is confident (say at the 68% level) the profitability will equal or exceed.* This lower limit is our Y_{ME}, the minimum expected profitability at the $1-\alpha$ level. If the decisionmaker is a risk-taker, then his choice of α may be very large. If

*Galbraith (1969), lends support to the contention that loss risk aversion is an important consideration for most businesses. Also see Herfindahl (1969, pp. 113 ff.) with regard to public agencies.

he demands little risk, his choice of α will be small. Those readers familiar with decision theory will find this concept analogous to March and Simon's Satisficing Principle (March and Simon, 1958).

The function of information gathering can be viewed as a procedure to adjust Y_{ME} to a higher value or to reduce the risk associated with the original estimate. Indeed, it is perhaps legitimate to say that the value of the information gained is equal to α times the change in this lower limit.

This is a provisional position which we need not dwell on here. The writer has been unable to find any treatment of the subject in the literature. It seems intuitively clear, however, that, if the decision in question is truly to be made on the basis of such a minimum expected value, then there is only an α chance that a change in Y_{ME} will ultimately prove to be the fact in profitability. Thus, valuations being made now, without the knowledge of what profitability will actually be, must be done in light of that probability. It is only necessary to recognize that the decisionmaker will theoretically consider both the risk that he is willing to bear and the inherent qualities of the information available.

The selection of the appropriate risk aversion level is problematic. In addition to the personal,

psychological aspects, the facts surrounding the situation are pertinent. As implied above, the symmetry of the risk would be of particular interest with heavier emphasis usually being placed on adverse or downside risk. The cushion that the individual or organization has above some minimum subsistence level would also influence the aversion to risk. If the project is very large in comparison to the total array of factors which influence his welfare, the decisionmaker would undoubtedly tolerate less risk than if the project is very small. Other factors (e.g. flexibility for change in the project) have additional impacts.

Risk aversion is a rather complex behavioral phenomenon which is not our object of study here. Some fairly standard assumptions will be made in order to facilitate focus on our main area of interest, and no further discussion will be provided.

It should be noted that we are presuming a change in Y_{ME} due solely to a tightening of the distribution about Y_{BE} (see O'Regan and Arvantis, 1966). No change in the mean is assumed to occur when additional information is gathered. In actuality the mean may move with additional information, but this cannot be known *a priori*. We can, as will be shown below, predict a tightening of the distribution, however.

Thus, we assert that the predicted marginal value

of product (MVP) of information activities is a function of the change in Y_{ME} which, in turn, is a function of the change in the sampling error of Y. Thus:

$$MVP = \alpha \cdot \Delta Y_{ME} \tag{4}$$

$$\Delta Y_{ME} = t_{1-\alpha}\left\{\Delta\sqrt{V(Y)}\right\} \tag{5}$$

In our productive process model, which had fixed inputs and outputs:

$$Y_{BE} = Q_1 P_1 + Q_2 P_2 + Q_3 P_3 + Q_4 P_4 \ldots Q_n P_n \tag{2}$$

It can be shown that:*

$$V(Y_{BE}) = Q_1^2 \; V(P_1) + Q_2^2 \; V(P_2) \ldots Q_n^2 \; V(P_n), \tag{6}$$

if the variables are independently distributed. If they are not independent, covariance terms must be introduced, but the basic technique for accumulating variances remains the same.

Our interest is, of course, in the change in the sampling error or the square root of the variance of Y. It can be shown that if:

$$\sqrt{V(Y_{BE})} = \sqrt{Q_1^2 \; V(P_1) + Q_2^2 \; V(P_2) \ldots Q_n^2 \; V(P_n)}, \tag{7}$$

* See Cochran (1963, pp. 90 ff.)

then:*

$$\Delta \sqrt{V(Y)} \cong \tfrac{1}{2}\{V(Y)\}^{-1/2}\{Q_1^2\,\Delta V(P_1) + Q_2^2\,\Delta V(P_2) + \ldots + Q_n^2\,\Delta V(P_n)\} \qquad (8)$$

Therefore:

$$MVP \cong \alpha \cdot t_{1-\alpha} \cdot \tfrac{1}{2}\left(V(Y)\right)^{-1/2}\left(Q_1^2\,\Delta V(P_1) + Q_2^2\,\Delta V(P_2) + \ldots + Q_n^2\,\Delta V(P_n)\right) \qquad (9)$$

We now have a single, integrated function which predicts the value of information to be gathered. As will be shown below, this is almost certainly a decreasing function as more and more information is gathered. According to classical marginal analysis, it is rational to continue to expend resources until the marginal value reaches the marginal cost. That point should determine the size of the total budget.

This equation requires that: (1) one have an estimate of the Q_i's or relative impacts, (2) that one have an estimate of the variance of Y_{BE}, which, as shown above, is an aggregation of the errors about the individual factors, and (3) that we know what the expenditure of each additional unit of resources will procure in terms of changes in the variances of the several P's. It says nothing about how to allocate the marginal dollar between work on the several $V(P_i)$. This is the subject of the next model.

* See Hart (1963, pp. 92 ff.)

It was shown above that:

$$V(Y_{BE}) = Q_1^2 \; V(P_1) + Q_2^2 \; V(P_2) \ldots Q_n^2 \; V(P_n), \tag{6}$$

If we take as fixed, some budget total, C_T, such that the sum of the budget items devoted to the individual factors (C_i) is equal to C_T, then our immediate problem will be to allocate C_T among the C_i's in a manner which will gain the largest possible reduction in $V(Y_{BE})$. In other words, the more money we spend on investigation of a given factor, the lower will be its variance and its contribution to overall variance, <u>but</u> the more money we spend on that factor, the less we can spend on another. What we need is an allocation rule which will provide the maximum reduction in $V(Y_{BE})$ subject to the constraint that:

$$\Sigma C_i = C_T \tag{10}$$

Let us assume for a moment that all of our investigations are matters of sampling. This is obviously not very realistic, and the assumption will be dropped shortly after it has served some expository purposes.

We know that:

$$V(P_i) = \frac{\sigma_i^2}{n_i} \tag{11}$$

and that:

$$n_i = \frac{C_i}{k_i} \tag{12}$$

Where:

σ_i^2 = population variance of the ith variable

n_i = number of samples taken on the ith variable

C_i = budget devoted to the ith variable

k_i = cost per sample of the ith variable

Thus:

$$V(P_i) = \frac{\sigma_i^2 k_i}{C_i} \tag{13}$$

and:

$$V(Y_{BE}) = Q_1^2 \frac{\sigma_1^2 k_1}{C_1} + Q_2^2 \frac{\sigma_2^2 k_2}{C_2} + \ldots \tag{14}$$

Now we know from classical statistics (e.g., Cochran, 1963) that optimum allocation in such a situation requires that C_T be distributed according to the rule:

$$C_i = \left[\frac{Q_i \sigma_i \sqrt{k_i}}{\Sigma Q_i \sigma_i \sqrt{k_i}}\right]\left[C_T\right] \tag{15}$$

This provides a unique solution to the allocation problem, which is, in theory, optimum. The assumption above, stating that all investigation is a matter of sampling, relegates the unique and optimum allocation to the arena of pure theory unless we can somehow re-

lax the assumption.

Equation # (13) tells us that the sampling variance of P is a function of the population variance, the cost per sample, and the sub-budget devoted to it. If we could estimate $V(P_i)$ in terms of C_i only, and could, in turn, integrate these expressions into the optimum allocation scheme, we could make some approach toward an operational system.

It is asserted that, in making these allocations, astute decisionmakers do, in fact, attempt to estimate, in a probability sense, their level of error about each factor and how much each additional dollar spent investigating will reduce these errors. For certain types of information projects, published estimates could be used (e.g. Husch, 1971, and Julian, et al., 1969). This procedure might be illustrated as in Figure 3.

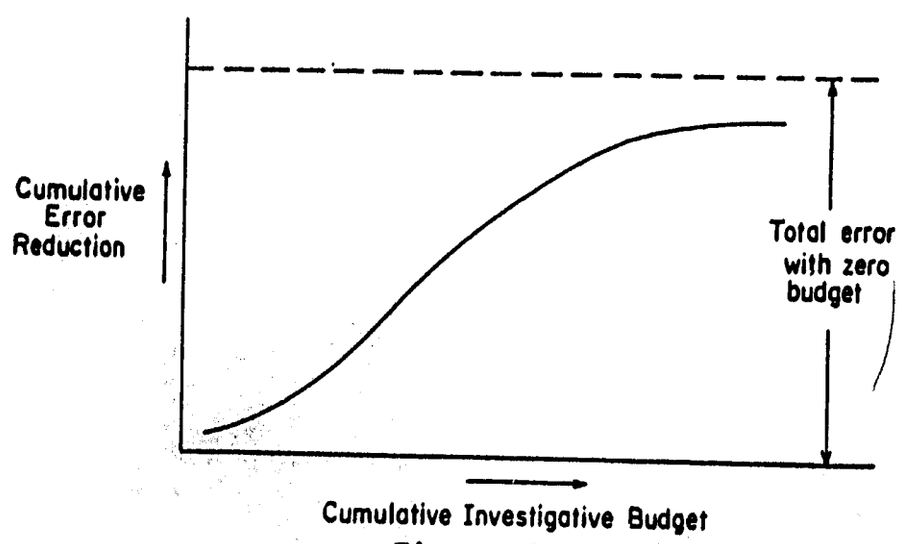

Figure 3

The curve in Figure 3 will probably be asymptotic to complete certainty and might take some form such as:

$$y = e^{a - \frac{b}{x}} \tag{16}$$

where y is the total reduction in error and x is the cumulative budget.

The form of the curve is relatively inconsequential so long as $\Delta V(P_i)$ can be expressed in terms of C_i.

Now let us go back to our equation where:

$$\Delta \sqrt{V(Y)} \cong \tfrac{1}{2}\left\{V(Y)\right\}^{-\frac{1}{2}} \left\{Q_1^2 \Delta V(P_1) + Q_2^2 \Delta V(P_2) + \ldots + Q_n^2 \Delta V(P_n)\right\} \tag{8}$$

If:

$$\Delta V(P_i) = f(C_i) = e^{a - \frac{b}{C_i}} \tag{17}$$

then:

$$\Delta V(Y_{BE}) \cong \sqrt{\tfrac{1}{2}\left\{V(Y_{BE})\right\}^{-\frac{1}{2}} \left\{Q_1^2 f(C_1) + Q_2^2 f(C_2) + \ldots Q_n^2 f(C_n)\right\}} \tag{18}$$

$$= \sqrt{\tfrac{1}{2}\left\{V(Y_{BE})\right\}^{-\frac{1}{2}} \left\{Q_1^2 e^{a_1 - \frac{b_1}{C_1}} + Q_2^2 e^{a_2 - \frac{b_2}{C_2}} + \ldots Q_n^2 e^{a_n - \frac{b_n}{C_n}}\right\}} \tag{19}$$

With regard to the estimation of the Q_i's, we have other problems. If the ultimate production func-

tion (i.e., the basic productive process the inputs of which we are investigating--not the information production function) is not quantified, the relative weights cannot be assigned. Should this prove to be an obstacle, there are techniques available for estimating these relative values directly. (See the relevance matrix technique, for example, in Summers, 1969).

Now, while the mathematics from Equation (19) became very complex, there is a unique combination of C_i's (where $\sum C_i = C_T$) which will maximize $\Delta V(Y_{BE})$. That combination is the optimum allocation.

Now, if we take a series of C_T's and, using this optimum allocation rule, calculate the maximum reduction which can be had for each of several budget sizes, then the graph of the overall error would follow the same form as Figure 3 and would have the additional characteristic that any given error reduction on the curve would be as far to the left as possible. That is, since the reduction in errors about individual factors are generally sigmoid and asymptotic to certainty (or some fixed level of uncertainty), then the aggregation into the overall error, constantly holding an optimum combination, would also be sigmoid and asymptotic to certainty.

Thus, the results of the direct cost estimates

could be plugged back into Equation (9) to obtain estimated MVP for the information project.

If we define Y_{MA} to be the minimum acceptable outcome as discussed above, the budgeting rationale can be summarized as follows:

	<u>If</u>:	<u>Then</u>:
(1)	$Y_{BE} > Y_{MA}$ $Y_{ME} < Y_{MA}$ $MVP > 1$	Budget too small
(2)	$Y_{BE} > Y_{MA}$ $Y_{ME} < Y_{MA}$ $MVP < 1$	Budget too large
(3)	$Y_{BE} > Y_{MA}$ $Y_{ME} > Y_{MA}$	No budget necessary; positive decision
(4)	$Y_{BE} < Y_{MA}$ $Y_{ME} < Y_{MA}$	No budget necessary; negative decision

Thus we have both a defensible budgeting rationale and a defensible means of internally allocating the budget to the several information activities. While this is probably not the only way to look at the budgeting and allocation procedures, it is hypothesized that any system which provides microeconomic rationale

for these activities must include the basic design parameters used here.

It should be noted here that the models depend on a number of assumptions which must be met in order for the system to provide workable guidelines. These include:

(1) That decisions about information generation are made in an identifiable manner (i.e. they can be separated for study if desired) but are made in the context of the more ultimate program for which they supply information. Therefore, the same kind of profit or benefit/cost analysis will apply, at least conceptually, to the information part of the overall program as to any other part.

(2) There is some single measure of success (perhaps proxy) with regard to the overall organization objectives. To achieve higher levels of success is more desirable than to have a lower level.

(3) The perceived need for decisions is exogeneous. That is, the perceived need for a decision occurs and an information generating undertaking is planned as part of the response. During the course of information generation, new needs for decisions may arise, and demands for new information may result, but the original plan is the item of interest.

(4) The appropriate α level is known and consist-

ent. That is, the risk aversion for the decisionmaker who will use the information is known to the designer of the information package.

(5) The ultimate decision(s) for which the information is being produced will be made on the basis of some maximum liklihood indicator, such as Y_{BE} and/or on the basis of a lower limit, such as Y_{ME}. The intermediate decisions regarding the information activities will be made on the basis of Y_{ME}.

(6) The state of knowledge is never zero about anything. The decisionmaker always has some idea about each variable that he perceives to be important in terms of the ultimate organizational decisions. If the one who designs the information package is not the same as the one who makes the ultimate decisions for which the information is produced, then a transfer of these "states of knowledge" takes place.

These assumptions and the actual procedures for operation provided the subject for the field study, which is reported in Chapter IV. Computerization of the model and sensitivity analyses are reported in Chapter III.

Chapter III

A HYPOTHETICAL CASE AND ITS RESULTS

After the theoretical models described in Chapter II were completed it was desired to test them. Field studies were designed and carried out. As a part of this testing a "decision game" was developed and applied. The game and its results will be reported in this chapter. This will not duplicate precisely the sequence in which the research was carried out but it is believed that it will provide a more easily understandable report for the reader.

The purpose of this decision game was threefold: (1) to work through a specific example of the general model outlined in Chapter II, (2) to see if thoughtful but intuitive solutions to the budgeting and alloca-

tion decisions could approximate the mathematically "optimum" solution, and (3) to test the model for sensitivity (i.e. to see what effects on budgeting and allocations small changes in the design parameters might have).

As will be detailed below, a prototype of this game was first developed in Central America, and exploratory applications were made. Since the reactions were rather negative, it was temporarily abandoned while the case studies were completed. After return to the U.S., the game was redesigned (i.e. translated into English, converted to U.S. dollars, and some other adjustments made). A computer program was written which would perform the mathematics, and a mathematically optimum solution was obtained. Using the program, sensitivity analyses were made. Then applications to decisionmakers were again attempted. Methods used for these activities are described below, and the results are detailed.

Development of the Exercise

A hypothetical situation was described which clearly fit the basic model envisioned. It was set in terms of a profit-maximizing private enterprise in order to avoid the trade-off problem between the mul-

tiple objectives of a public organization. A straightforward investment decision was to be made, but an intermediate decision was needed regarding the types and amounts of information to be generated. Complete knowledge was given to the participants regarding the selection of variables and the current subjective errors on them, as well as their relative impacts and costs of investigation. Only three variables were involved. The decisionmaker was asked to state how much he would spend on information gathering and how he would divide this amount between the relevant variables. A copy of the game is included in Appendix III.

Mathematics and Computer Program

The model on which the decision game is based can be described as follows:

$$Y = A + W_1F_1 + W_2F_2 + W_3F_3 \ldots \quad (20)$$

Where:

Y = Overall profitability (which can be capitalized into present value with an interest rate "R")

A = A fixed quantity which encompasses all the factors affecting profitability and about which the decisionmaker has relative certainty

W_i = Individual weights derived from relative impacts of that factor on profitability

F_i = Factors determining profitability about which the decisionmaker does not have relative certainty

Therefore, assuming for the moment that the errors on the individual factors are independently distributed:

$$V(Y)=W_1^2 V(F_1)+W_2^2 V(F_2)+W_3^2 V(F_3)\ldots. \tag{21}$$

Where:

$V(Y)$ = Uncertainty about the overall profitability (or present value) expressed as the variance of Y

$V(F_i)$ = Uncertainty about the true value of the determinants of profitability expressed as the variance of F_i

We assume that the future size of the uncertainty is related to the amount of money we spend on investigation of the individual factors. For convenience,* we assume that:

$$V(F_i)=a_i/b_i^{C_i}+P_i \tag{22}$$

* Other shapes of this information production function could be assumed, but would require redoing the mathematics which follow.

Where:

a_i and b_i = Appropriate coefficients derived from best fit curves

C_i = The amount of the budget devoted to investigation of the ith factor

P_i = Estimated level of residual error which cannot be reduced by additional investigation

Since we know that the sum of the budgets we spend on the investigation of the several factors must equal the total budget, then:

$$\Sigma C_i = C_T \tag{10}$$

By substitution of the information production functions into the overall variance function, taking the partial derivatives of that function with respect to the several individual budgets, setting these partial derivatives equal to zero and solving simultaneously, it is possible to mathematically minimize V(Y) for any given total budget.

A computer program in BASIC was written for the College of Forestry's time-sharing terminal which would carry out these mathematical operations for a specified series of total budgets. Copies of the program are available from the author for those interested. The program requires estimates of: (1) relative im-

pacts of the various factors, W_i, (2) levels below which uncertainty cannot be reduced, P_i, and (3) the coefficients for the information production curves, a_i and b_i. In addition, a series of possible total budgets (completely arbitrary) is introduced.

The output of the program (see an example in Appendix III) is essentially twofold. First, it calculates and prints the optimum allocations, as determined by the above procedures, for the specified series of total budgets. Then it calculates and prints the predicted errors on the individual factors and on the overall outcome for the same series of total budgets.

It is interesting to note that the original program written, often produced negative budgets for certain variables. It was first thought to be an error in programming, and only slowly was it realized that no constraint had been built into the program to prevent the information production function from extending to the left of the Y-axis. In effect, the computer was trying to get a refund on the current states of knowledge on some of the variables. Unfortunately, in the real world, that cannot be done. Therefore, a constraint was introduced into the program to make all budgets equal to or larger than zero.

Application and Results of the Game

After the modeling and computerization was completed, a concise description was written which would supply the participant with the necessary and sufficient information to determine the optimum balancing of effort between the variables and, with the risk aversion appropriate to his own psyche, to determine the total effort which he should devote to information gathering.

The first attempt to apply the game was with six graduate students. Although they were generally quite capable, had a rather leisurely schedule, had good backgrounds in mathematics (and in some cases, computer modeling), and were eager to understand, they had very little professional experience in actually making decisions as to how much information to generate.

The second group of individuals to which the questions were asked was made up of six well-experienced professionals in the consulting firm with which the author is currently associated. Although well-schooled (and highly successful) in the practical aspects of making such decisions on a day-to-day basis, they were generally not well acquainted with the techniques of computer modeling, information theory, or even the standard theory of marginal analysis. Their

attitude might be best described as forbearing. That is, they found it interesting but a rather foolish waste of time which they would tolerate to assist a colleague.

The results of the exercise indicates that, in the simple situation described, it is possible to intuitively approximate the mathematically optimum solution. The consultants tended to be satisfied with a lower level of certainty, and they internally allocated the effort somewhat more efficiently than did the graduate students. As Table I indicates, however, even the graduate students placed the heaviest and highest emphasis on the correct variables.

TABLE I

Comparison of average total effort in man-days suggested by graduate students versus consultants and internal allocation to variables

	Variables			Total
	Timber	Labor	Markets	
Arithmetic mean (Consultants)	5.9	2.8	.8	9.5
Computer allocation	6.7	2.8	0	9.5
Arithmatic mean (Graduate students)	9.2	6.2	3.3	18.7
Computer allocation	12.0	6.7	0	18.7

Although the difference between the two groups as to the total effort to be expended is rather large, it is not statistically significant. A standard "t" test indicates an 18.5% chance that the difference is random only. Another possibility is that the graduate students tended to have a higher risk aversion than the consultants. There might also have been some technical differences in the methods of arriving at the solution. No answer can be given with certainty.

At a more subjective level, all six of the consultants had a great deal of difficulty in focusing on the information decisions as opposed to the investment decision. They also were consistent in demanding to know the source of the functions presented to them. These two aspects were far less evident among the graduate students.

Sensitivity Testing

Using this computer program on the time-sharing terminal, the basic design parameters for the hypothetical case were systematically varied in order to observe what effects errors in estimating these design parameters would have on the budgeting and allocation guidelines produced. While it is mathematically possible to predict the qualitative changes that will take place with regard to allocation, the magnitudes

of the changes depends on the specific situation.

With regard to total budgets needed, we have a more difficult problem. Whether allocations are optimum or not does not determine how much risk the decisionmaker is willing to assume. As noted earlier, risk aversion is not a subject under study here. Therefore, the output of the model provides a series of possible total budgets and their allocations. The choice which the decisionmaker ultimately makes is an expression of: (1) the technical characteristics of the hypothetical situation described, and (2) of his own personal aversion to risk and the decision criteria used to express this risk aversion. They cannot be separated.

If we take as given the risk aversion and the choice of decision criteria, then both the appropriate size of total budget and the internal allocation are, theoretically, completely dependent on the estimation of the three design criteria. Sensitivity testing with the computer model provided some interesting insight into the design process.

Estimation of the relative impacts of the variables is fairly straightforward. If impacts are overestimated for a given factor, the amount allocated to that factor will be excessive. That overestimation will also contribute to an excessively large estimate

of needed total budget. If the impacts of all the items in an information package are overestimated, the internal allocation might approach optimum, but the estimated total budget needed to reduce uncertainty to an acceptable level might be so large as to require rejection of the entire productive project. Underestimation of impacts will, of course, have just the opposite effect.

Ironically, total estimated error sizes have no effect on the allocation of budgets. The <u>change</u> in error size is the relevant parameter. An overestimate or underestimate of error size, however, will contribute (in the same manner as overestimated or underestimated impacts) to the estimated total budget needed.

The information production function (or the estimated change in error size per dollar spent) is the most complex of all the parameters. The form assumed for the computer model was:

$$V(F_i) = a_i / b_i^{C_i} + P_i \qquad (22)$$

When this function is evaluated at $C_i = 0$ (or when no budget has been devoted to error reduction and we have the current state of knowledge), the quantity, bi^{Ci}, becomes equal to one, and the uncertainty is the sum of a_i and P_i. When we let C_i equal a very large

number, the quantity, $a_i/b_i^{C_i}$, approaches zero* and $V(F_i) \cong P_i$. The quantity, P_i, is uncertainty which cannot be removed, while a_i is the "changeable" error. The size of P_i has no effect on allocation since the change in estimated error size is the relevant criteria. Underestimates or overestimates of P_i do contribute to total uncertainty, and therefore, to estimated total budget needs for information.**

Therefore, the most critical elements in the information production function become a_i and b_i, which are, respectively, the initial amount of changeable error, and the rate at which the error can be reduced. Both of these design parameters effect both allocation and total budget needs. In the computer model, small changes in either one had substantial effects on design.

The practical implications of the computerized model remain conjectural. A computer program was written for the hypothetical situation. That situation

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* The quantity b will always be a positive number larger than one.

** The values actually used for the three information production functions were:

Variable	a	b	P
Timber	2050	1.21	450
Labor	0.17	1.16	0.08
Price	2.70	1.15	5.30

was highly idealized, however, and serious doubt existed concerning the likelihood of optimization of real-world situations. Therefore, discussions were conducted with several individuals knowledgeable in statistics, computer programming, and operations research. The consensus was as follows.

It would probably be possible to obtain truly optimum solutions to slightly more complex problems than that described. More variables could be handled and non-linear impact functions could be incorporated without major programming difficulties.

As the information production function becomes more complex, mathmatically optimum solutions may become inherently impossible. In these cases, simulation techniques could perhaps be developed to approximate the optimum solution. It may be possible to compute some guidelines or dominated strategies with incomplete probability distributions (Fishburn, 1966).

If we introduce the realities of ill-defined trade-offs between objectives, poorly known production processes, joint costs of information productions, etc., it becomes overpoweringly evident that hopes for computerizing real-world design processes can be effectively dismissed.

Chapter IV

THE FIELD STUDY METHODOLOGY AND RESULTS

After the theoretical models presented in Chapter II were completed, a plan was devised for field study to test their validity and practicality. Essentially, the interest centered around five questions:

(1) Are the basic assumptions which go into the models, particularly regarding the decision scheme, a valid and useful way of describing the actual situation with regard to natural resource information projects in Central America?

(2) If they are not, what other assumptions might be more realistic?

(3) With regard to the funding and allocation procedures, are any analytical methods, such as those

outlined, used, and if so, how are cost, impact, and error estimates made, and how are they integrated into decision guidelines?

(4) If analytical procedures such as these are not used, why are they not used?

(5) If these are not used, what would be required for, and what would be the results of, the introduction of such methods?

To develop insight into the five questions posed above, a two-part study was needed. The first phase would explore Questions (1) and (2) regarding the basic decision scheme. Then, depending somewhat on the results of the first phase, a second phase would be needed to treat with greater specificity the last three questions.

The Case Studies

The study plan devised to satisfy these needs was essentially a case study approach. The researcher was to move to Central America and spend several months doing in-depth analysis of several information projects. These analytic exercises would treat the framework in which design of the information systems took place and how the specific elements of design (e.g. information generation costs, error estimation, impacts of errors, etc.) were, and could be, handled.

After the selection and preliminary work on the first one or two of these case studies, an assessment of the validity of the decision framework would be made and appropriate adjustments in the second phase would be worked out. Then, as time allowed, other case studies would be added. Both phases of the case studies were to depend rather heavily on interviews and study of relevant documents.

The actual field studies followed the plan with some relatively minor variations. Immediately upon arrival in Central America, several possible information projects were identified and exploratory discussions begun. Eventually, two case studies were selected (both in Guatemala) and in-depth analysis begun.

After the first phase of the first two case studies were completed, a reassessment of the basic models was made. Detailed results of this will be presented below, but in quick summary, it seemed that the basic models were generally good, although certain aspects would require significant revision. It appeared at that time that the major design parameters, identified by the theoretical work, remained valid.

Therefore, these case studies were completed and others, up to a total of six, were identified and carried out. These six case studies involved about 25 decisionmakers. More detailed descriptions of each of

the case studies are presented in Appendix I, but they included:

- A five-year land-use study in the altiplano of Guatemala.
- A feasibility study for the establishment of a forest reserve in Costa Rica.
- A continuing program for gathering forest products statistics for Guatemala.
- The information generating portion of the forestry sectoral plan for the Central American Common Market.
- A cooperative mapping project between NASA and the Guatemalan mapping agency.
- An ecological reconnaisance by a private consultant of a hydroelectric project in N.W. Columbia.

These case studies were selected so that at least some of the basic assumptions would be fulfilled. That is, they were all information gathering projects aimed at generating data to assist in the achievement of some social function. The decisionmakers involved had to be willing to cooperate in such a study and the writer had to be able to finish the analysis within the time and monetary limits available. It is impossible to rigorously evaluate how representative these projects and decisionmakers are. No claims to broad representativeness are made. The writer knows of no reason why they would not be a reasonable cross-section of the kinds of projects described.

The choices of who to include in the interviews were made in as comprehensive a manner as possible. There was an attempt made to interview everyone who appeared to have had a significant impact on the design of the project. They included individuals classified as funding sources and their advisors, as information producers and their advisors, as well as information users and their advisors. On several occasions extensive discussions were conducted with individuals who were not directly involved in the design of the project but who were knowledgeable about the designing process which had taken place.

Methodology for the individual case studies required some flexibility to suit each situation. In general, however, it followed the outline which is presented below.

First the basic five questions above were broken into their component parts and a more detailed list of questions was produced. This list, containing some 35 questions, will provide the frame for presentation of results below. In most cases these questions were too threatening to ask the respondents directly. That is, many of the specific questions, if asked directly to the respondents would have, (1) forced them into the position of either openly revealing poor management or bragging about his accomplishments--neither of which

they seemed to be willing to do--or, (2) been so broad in scope as to have required a good deal of conceptual organizing--which they did not seem to be willing to do.

Therefore, a third list of questions was compiled which could be, indirectly, used to infer answers to the more basic ones. The final questionnaire, which gave about 75 questions from which to choose, served as one of the fundamental inputs for the formal, recursive interviewing. A copy of the questionnaire is presented in Appendix II. The more basic questions are presented below.

BASIC QUESTIONS TO BE TREATED

I. Are the basic assumptions which go into the models, particularly regarding the decision scheme, a valid and useful way of describing the actual situation with regard to the natural resource information projects in Central America?

A. 1. What appears to be the real motivation for the information project?

2. Is it to supply knowledge for some resource allocation decisions?

B. Does there seem to be a serious attempt to produce the maximum amount of informa-

tion for a fixed budget or to minimize the needed budget to achieve some level of information?

C. Is the appraisal being done in a context of well-defined organizational goals, and do the decisionmakers have a sensitive means of determining how well these goals are being achieved?

D. What seems to be the source of the proposed changes which necessitated the information project?

E. 1. Does the question, "Am I confident enough...?" really seem to occur, and if so, is it answered in accordance with some consistent criteria?

2. Does this criteria seem to be an "equal to, or better than" minimum?

F. 1. Are the designers of the information project the same ones who will use the information in decisionmaking?

2. If they are not, do they seem to understand the ultimate organizational objectives?

3. Do they seem to design the program with the idea of these objectives

in mind?

4. Do they agree with them?

II. If the basic assumptions do not seem to be valid and useful, what other assumptions might be more realistic?

A. What is the relation of the information user to the information producer, and of both of these to the funding-source?

B. Are there other organizational objectives apparent in addition to those given by discussion and documents?

C. What other elements should be included in a more realistic decision scheme?

III. With regard to the funding and allocation procedures, are any analytical methods, such as those outlined, used, and if so, how are cost, impact, and error estimates made, and how are they integrated into decision guidelines?

A. 1. What are the important design parameters that are currently being used?

2. Are each of the specific parameters used in the theoretical models included among them?

3. What others are included?

B. 1. How are these estimated?

2. Are there quantitative procedures?

C. How are they put together to provide guidelines?

IV. If analytical procedures are not used, why are they not used?

A. 1. Does the funding-source demand justification for the resources invested in information?

2. Are there other pressures to force the information designer to carry out a rigorous design procedure?

B. 1. What kind of personnel are making the design decisions?

2. What is their level of education/experience, pay, and prestige?

C. Are there positive rewards for not using an analytical approach?

V. If these are not used, what would be required for, and what would be the results of, the introduction of such methods?

A. 1. Does the decision scheme necessarily have to be like the one originally presented in order to use such analytical methods?

2. Could this analytical design approach be applied to a less ideal

scheme in this situation?

B. 1. Are the goals well defined and can "prices" be attached to each?

2. What changes in the normative system would be required here to introduce it into practice?

C. 1. Are personnel aware of a wide range of technologies in order to conceptualize the productive system?

2. Is there agreement about which one is appropriate?

3. Is it necessary that there be?

4. If they understood only one in this case, would it be good enough?

D. 1. Do the information system designers seem to be aware of what current knowledge level the user has?

2. Is there a large difference between the knowledge level of the producer and the user?

E. 1. Is it necessary to define the current state of knowledge in these quantitative ways?

2. How can the change in the state of knowledge be indicated in other than this quantitative way?

F. 1. Do the impacts flow completely from the "prices"?

2. Can they be estimated in some other way?

G. 1. How closely must we estimate costs of error, changes, and impacts?

2. How sensitive is the allocation and funding rationale to errors in the estimate of impacts and errors?

Other questions for the interviewing (in addition to the questionnaire, which was based on the above questions and is presented in Appendix II) were derived from documentation study. This documentation, mostly in Spanish, ranged from internal, informal correspondence to formal, published reports. These documents, of course, provided direct information and insight into the questions, as well as providing a basis for the interviewing.

In an attempt to provide additional insight into the current practice, the "decision game" described in Chapter III was invented. An attempt was made to have several of the information project designers "play" the game. This approach, however, did not appear to be very fruitful at that stage and threatened to alienate them from the more productive interviews so it was temporarily abandoned. The full development

and application of the game had to await return to the U.S.

Results of the Case Studies

These case studies were exploratory, largely subjective, somewhat impressionistic and often non-independent. From the standpoint of rigorous scientific research, the results are reflective of these characteristics. Nonetheless there is some amount of consistency. Where consistencies (or divergencies) emerged in a meaningful way they will be reported.

The pattern of the report will follow the outline of questions shown above with a summary of results at the end of each of the five major questions.

I. Are the basic assumptions which go into the models, particularly regarding the decision scheme, a valid and useful way of describing the actual situation with regard to the natural resource information projects in Central America?

A. 1. What appears to be the real motivation for the information project?

2. Is it to supply knowledge for some resource allocation decisions?

Most of the decisionmakers studied were public employees in one form or other. Determining how they

might "maximize net social welfare" was not possible in any definitive way. All of the agencies, however, had certain social functions to perform. The fact that the organizations came into being and continue to exist implies that these functions are desirable and the organization's pursuit of them is their method of "maximizing net social welfare". The efficiency with which they carry out their social function can therefore be seen as some measure of their "profitability". Clearly, that measure is not as definitive as would be the case with the private firm particularly with regard to the question of tradeoffs between multiple social functions. It nonetheless served as a surrogate for most of the decisionmakers studied.

For the six case studies reported, there were a total of approximately 25 decisionmakers who had major impacts on the design of the information program. In-depth interviews were carried out with all but one of these. The results were somewhat subjective but rather revealing. First, it became evident that the decisionmaking structure was much more pluralistic than originally envisioned. In all of the examples studied the social function required resource allocation decisions and the information package was outwardly designed to supply input for these decisions. However, the forces which shaped the final information package

were, in almost all of the cases, highly diverse. The organization which supplied the funds had motivations X, Y, and A, in that order. Another organization, or another level in the same organization, supplied the broad outline and identified major variables based on motivations Y, W, and X, in that order. Another individual drew up the final specifications and suggested techniques based on motivations Y and V, while the person who actually gathered the information and compiled it for the user was motivated by U, Y and Z. The user needed the information for activities motivated by W, Y and T.

While there is enough overlap in the basic motivations of the several decisionmakers to assure sufficient cooperation to produce the information, that common set is not necessarily the ostensible social functions which are to be achieved. In addition to the ostensible social functions to be achieved and the "constrained" self-interest, basic motivation seemed heavily oriented toward organizational maintenance and growth (both appropriate and inappropriate) and occasionally by some rather "unconstrained" self-interest.

The original theoretical model postulated that the decisionmaker, in all cases, is motivated by a desire to maximize the social objective he was pursuing, namely better resource management, and that all of his

decisions regarding what information to generate will be based on that motivation. Such was obviously not exclusively the case in the examples studied. It is far more complex than that.

B. Does there seem to be a serious attempt to produce the maximum amount of information for a fixed budget or to minimize the needed budget to achieve some level of information?

In each of the examples there was some evidence of a sincere attempt by the people involved to have a "good" information package. In all cases except one, that meant some attempt to get the maximum amount of information for a fixed budget. In the one exception, the effort seemed to have been to produce some fixed level of information for "whatever it costs". The expenditures were not being kept down very well, but the results demanded were being rigorously defined. In that case, the range of possible costs in relation to the subject being considered was small as to be thought almost inconsequential even though some U.S. $30,000 was being expended.

C. Is the design being done in a context of well defined organizational goals, and do the decisionmakers have a sensitive means of determining how well these goals are

being achieved?

The theoretical models assumed that organizational goals had been well-defined and that tradeoffs between multiple goals were well understood. Such was not the case in the examples studied. None of the decisionmakers had achieved that condition (with the exception discussed below). The political realities of the organizations studied precluded definitive statements about organizational goals or explicit expressions of tradeoffs between multiple goals.

The only exceptions to this ambiguity that were evident concerned goals which were other than fulfilling the social function. In the majority of the cases studied, these other goals were the most clearly identified and they consistently dealt with organizational growth. In a large minority of cases, however, no goals were clearly identified and tradeoffs were unknown.

D. What seems to be the source of the proposed changes which necessitated the information project?

As indicated above, the information projects studied were not initiated solely in response to the need for information regarding some newly proposed program. Fundamentally, however, all the examples could be traced to four sources:

- Changes in physical environment, particularly changes in land-use patterns.
- Changes in social and economic characteristics, particularly population growth.
- Changes in technology, especially with regard to the techniques used for information production.
- Changes in organizational relations which permit organization growth and which (if we are generous) results from the first three.

While, in the analysis of individual information packages, it is useful to have an understanding of the question, generalizations in this regard have no meaning other than to define a type of information package to be analyzed.

E. 1. <u>Does the question, "Am I confident enough to make a decision about...?" really seem to occur, and if so, is it answered in accordance with some consistent criteria</u>?

2. <u>Does this criteria seem to be an "equal to or better than" minimum</u>?

Most of the decisionmakers did not ask the "Am I confident enough..." question in the same sense as in-

dicated in Figure 1. In two of the cases, it was explicitly stated at the onset that "we cannot proceed with the ultimate project until X level of information has been attained". In the other cases, a fixed budget for information was assigned and the entire amount was spent. The actual information output may have exceeded or fallen short of the desired level, but this had little effect on the program. Thus a continuous, sensitive feedback system was not present. At best, it is a one-step system with an arbitrarily determined cutoff.

Since the basic question regarding confidence of decisionmaking was not identified, the criteria for answering it could not be ascertained.

F. 1. <u>Are the designers of the information project the same ones who will use the information in decisionmaking</u>?

In each of the case studies, the individual or organization which had the greatest influence on the content of the information package was not the ultimate user. The user, in some cases, did have a substantial influence on the planning of the information package. In one other case the most important user was essentially not consulted.

2. <u>If they are not, do they seem to understand the ultimate organiza-</u>

tional objectives?

In terms of overall organizational objectives of the user, the most influential designer usually did not have a thorough understanding and were, in some cases, even antagonistic toward them. Of the 25 decisionmakers studied about one-fourth of them had little or no contact with the user.

In terms of achieving the social function of the user organization, there were some examples in which the information producer (the most influential factor on designing the package) acted in accordance with the myth that only the social objective mattered and thereby created a great deal of frustration on the part of the user. In at least two of the cases, it was evident that the producer of the information had a much firmer command of what was needed to accomplish the ostensible objectives of the user than did the user himself. In other cases, it was evident that working-level objectives had not been thought out on the part of anyone involved. Thus, the design of the information package could not have been done in those terms.

3. Do they seem to design the program with the idea of these objectives in mind?

4. Do they agree with them?

We are here discussing those who have a substan-

tial influence on the design of the information package but who are not the major user. In some of these cases, the designer seemed to have a good command of the social objectives of the user, was in full agreement, and attempted to design the package accordingly.

In other cases, the designer seemed to perceive the appropriate social function to be something other than that which the user perceived, and this difference had a substantial influence on the design.

To summarize the results of all parts of Question I for all the examples studied, it must be stated that the decision scheme originally envisioned is somewhat too simplistic. In these examples, decisionmaking was done on a much more pluralistic basis, motivation (and therefore, objectives) were much more complex, often ill-defined, but certainly not limited to achievement of the social functions. It was particularly revealing that the question, as asked in Figure 1, "Am I confident enough to make a decision about...?", did not occur. This indicates that, in terms of overall budget, there is little feedback involved and the cutoff does not particularly coincide with some overall level of accuracy or knowledge.

II. <u>If the basic assumptions do not seem to be valid and useful, what other assumptions might be more realistic</u>?

A. <u>What is the relation of the information user to the information producer, and both of these to the funding-source?</u>

As noted above, the individuals and organizations which had an influence on the design of the information packages studied were usually somewhat more complex than only these three. With some minor exceptions, the relationship between the various roles was marked by a uniform lack of coordination.

In some of the cases, the several decisionmakers were simply not in good communication and had little interest in cooperation, and there was no mechanism to facilitate communication or coerce cooperation. In spite of this lack of coordination, each of the units applied some of their energies to achieving some social function. There was, as evidenced by the existence of the information program, enough commonality to provide the necessary inputs.

B. <u>Are there other organizational objectives apparent in addition to those given by discussion and documents?</u>

While the organizational objectives were virtually never limited to the stated social functions, the other objectives were usually discussed in a fairly free manner. In fact, this researcher found the candor with which the decisionmakers discussed these other

objectives profoundly disturbing at times. The openness with which many were willing to discuss their objectives of leadership aggrandizement, apparently unjustified organizational growth, personal enrichment, etc., indicated a significantly different set of "acceptable" activities.

On two occasions, there were apparently sub rosa objectives which the decisionmakers refused to discuss and which did not appear worth the risk of alienation to pursue.

It should be emphasized that in every one of the case studies at least a substantial portion of the various decisionmaker's objectives did have to do with achieving the social function. That is our area of interest and the other objectives, open or sub rosa, will not be treated.

C. What other elements should be included in a more realistic decision scheme?

A more complete model would include multiple and largely independent decisionmakers rather than the monolithic structure assumed. It would include multiple objectives and some methods of making tradeoffs between them and would treat changes in technology in more depth than do those models in Chapter II.

To summarize the results of all parts of Question II for the examples studied, we must differentiate be-

tween a completely descriptive model which attempts to be totally realistic and more prescriptive model which strays from total reality but reduces complexities to a manageable level. The latter type was of interest here, and the basic models presented appeared to be a workable approach.

III. With regard to the funding and allocation procedures, are any analytical methods such as those outlined used and, if so, how are cost, impacts, and error estimates made, and how are they integrated into decision guidelines?

A. 1. What are the important design parameters that are currently being used?

2. Are each of the specific parameters used in the theoretical models included among them?

3. What others are included?

Since all three parts of IIIA are interrelated the results will be presented together.

First, it is clear that the 25 decisionmakers studied did not consistently design their information activities in this analytical fashion. The major theoretical parameters were occasionally considered by virtually all of the decisionmakers but never in a conscious, formal manner. Completeness and accuracy of

current knowledge about some variable being investigated was occasionally mentioned by an interviewee, but none indicated a rigorous assessment. The impact of errors in current knowledge was also occasionally mentioned but less so than errors themselves. The only one of the major theoretical parameters which was consistently evident in the minds of the decisionmakers appeared to be that of costs. However, costs were seldom mentioned in relation to reduction of error but, instead, only as it related to the budgeting of the organization. There appeared to be little awareness on the part of the decisionmakers of any analog of the α-level.

There was one design parameter which was consistently used by the decisionmakers which was not included in the theoretical models. This concerned utilization of existing organizational capability. That is, utilization of trained personnel, of equipment and of specialized techniques was given prime consideration in the design of most projects.

B. 1. <u>How are these estimated</u>?

2. <u>Are there quantitative procedures</u>?

When specific design parameters, such as those identified by the theoretical models, were used, they were assessed only in a very intuitive, qualitative fashion and, with some minor exceptions, were never

quantified.

The only exceptions were a few examples of quantitative cost estimates. In some of the cases, for some of the individual activities, cost estimates were made for various levels of precision. In all of those cases, however, the estimates were viewed as some type of exploration of various techniques and sequences of techniques rather than quantification of the relation of budgets versus knowledge levels.

C. How are they put together to provide guidelines?

Since most of the parameters needed for decisions were not quantified, the integration of the various influences on design was totally intuitive. There were no examples of quantitative estimates of aggregate errors or of allocation formulas.

To summarize the results of Question III, it is safe to say that rigorous analytical design procedures did not exist in any of the examples studied. Why they did not exist will be discussed under Question IV, below. In spite of the lack of a quantitative approach, it is evident that many of the designers did have some inkling of the various theoretical design parameters needed and were influenced by them. Methods for (and results of) encouraging increased attention to the parameters will be discussed under Question V.

IV. <u>If analytical procedures are not used, why are they not used?</u>

A. 1. <u>Does the funding-source demand justification for the resources invested in information?</u>

In none of the cases studied was detailed <u>ex ante</u> justification demanded. Some of the information producers received support for the information generation activities as a separate activity. In these cases, the funding-source wanted to know what the funds were going to be expended for but did not request an analytical assessment of the type proposed.

Others of the producers used funds which were originally given for other purposes to generate the information. That is not to imply any fraudulent activity since information generation may be quite an appropriate part of any program. Rather, it only points out that the funding-source may not even be aware that the information activities were taking place, or did not consider them worthy of separate identification.

In most (but probably not all) of the cases, those in charge of the expenditure could look forward to some type of evaluation after the work was completed. That is, some <u>ex post</u> justification was, or would be, required. In only one of these would it be fair to

say that the demands would be rigorous. In all others, either the evaluation was fairly weak, or it was non-existent.

2. Are there other pressures to force the information designer to carry out a rigorous design procedure?

Other than the weak budgetary procedures treated above, there are few pressures for rigorous design procedures. One of these few, however, is fairly strong. It is perhaps best termed professional pride. In every case studied, most of the individuals who influenced design of the packages identified as "professionals" and brought with them to the decisionmaking some desire (and occasionally some ability) to use a thoughtful approach to such a problem. This internal pressure often appeared to be the only major source of guidance.

In addition, three or four of the decisionmakers (out of a total of more than 20) demonstrated a strong sense of social purpose unrelated to organizational growth or to high professional standards. An attempt to analyze this phenomenon would require a behavioral study, which is quite beyond the present interest. Suffice it to say that this strong sense of social purpose seemed to have a significant impact on the way these individuals attempted to influence design decisions *vis-a-vis* the organization and their own posi-

tion.

Thus, other pressures appear to exist but are much too subtle to treat in an exploratory study such as this.

B. 1. What kind of personnel are making the design decisions?

2. What is their level of education/ experience and pay-prestige?

All of the individuals who had substantial influence on the design of these information packages were at least moderately well educated and experienced. A number of U.S. and European Ph.D.'s were represented, as well as Ingenieros and Licenciados. Professional experience emphasized technical and engineering skills rather than socio-economic, although some of the individuals demonstrated well-developed command of socio-economic variables.

Likewise, all the individuals were compensated to at least a moderately high level, some holding extremely high paying and prestigious positions.

C. Are there positive rewards for not using an analytical approach?

In terms of progress towards a completely realistic set of objectives, there were positive rewards for not using an analytical approach if the analytical approach is set only in terms of the mythical object-

ives. This appears to be a valid statement regarding all of the examples studied.

If we adopt the myth as proposed, there still remains the positive reward of a quick and easy intuitive design versus a demanding and costly analytical design. Whether a well-balanced design can be had by a quick and cheap intuitive approach is, of course, subject to some debate.

To summarize the results of all parts of Question IV for those examples studied, we can state that, although the personnel involved were generally well educated, well experienced, and well paid, they did not use a very rigorous approach to design. There are perhaps three major reasons. First is that there was no particular demand for it. Second, there are positive rewards for not using such a design, especially with regards to objectives other than the social function. Thirdly, the decisionmakers themselves apparently felt that the time and effort required would not be repaid by the impact that it might have on the information package.

V. <u>If these are not used, what would be required for, and what would be the results of, the introduction of such methods?</u>

A. 1. <u>Does the decision scheme necessarily</u>

have to be like the one originally presented in order to use analytical methods?

2. Could this analytical design approach be applied to a less ideal scheme in this situation?

Aside from being somewhat simplistic, perhaps the most fundamental characteristics of the decision scheme are that it is rationalistic, monolithic, and analytical.

In all the examples studied, there seemed to be some nonrational elements in the design. While there are some fairly deep semantic difficulties regarding the rational versus nonrational, it is plain that the theoretical models in Chapter II are not, and cannot be made to be, compatible with nonrational decisioning. To that extent it is inapplicable.

The fact that it is monolithic, whereas the true decision schemes appear more pluralistic, will not negate the value of the approach. If each of the multiple decisionmakers had used the approach, then each would have benefited from whatever value it might have to offer. The final balancing of influences which determines the design might remain the same.

By analytical, we mean the dissection of problems into smaller, more manageable units for more care-

ful consideration. Whether the analysis is quantitative or qualitative, and how the units are re-assembled into the whole again, is not the interest at this point. The question reduces to, "Could an analytical approach be applied to the real world of the cases studied?". This researcher holds the admittedly subjective opinion that it would have been possible and useful in every one of the cases studied to have thought through some scheme such as this.

B. 1. Are the goals well defined, and can "prices" be attached to each?

2. What changes in the normative system would be required to introduce it into practice?

This is perhaps the most difficult problem to resolve in the entire model. In none of the examples was it possible to arrive at an aggregate measure of outcome. All of the organizations have multiple objectives but could not state explicit tradeoffs between them. Therefore, if Outcome #1 comprises 10,000 units of X, 8,000 units of Y, and 16 units of S, while Outcome #2 comprises 8,000 units of X, 13,000 units of Y, and 2 units of S, there is inherently no way to determine which is more desirable.

The design of information systems, of course, is

not the only management activity that suffers from this lack. The more ultimate resource allocation decisions themselves cannot approach optimality unless explicit tradeoffs are available. In private enterprise, these tradeoffs are, according to classical economics, automatically achieved by the use of discounted dollar flows. It is not the purpose of this study to adopt the techniques of private enterprise to public organizations such as those studied. Since the basic information models were worked out on that basis, however, some solution will be required if quantitative applications are to be applied. Otherwise, there is no way to know what it will "cost" to be wrong about certain variables.

Operationally, information packages are designed and the more ultimate resource allocation decisions are made. Apparently the tradeoffs needed are arbitrarily determined on an ad hoc basis, are virtually always in a state of flux, and are almost never explicitly revealed. (For an interesting example of this with regard to the U.S. Forest Service, see: Keaton, 1972).

If quantitative solutions to the information models are desired, there are perhaps two possible approaches. One is to assume several possible values (or perhaps two extremes) and work through the models with each. The several possible designs should provide some

useful guidelines. The other approach is to assume a single normative set of tradeoffs and accept the output as normative. In the most fundamental sense, that is what is implied under current practice.

Quantitative solutions to the models are not necessarily the only values which come from the models, however. Other possibilities will be discussed below.

C. 1. Are personnel aware of a wide range of technologies in order to conceptualize the productive system?

In some of the examples, the individuals who had the greatest impact on the design did have a fair command of the productive process and, thus, had a fairly clear picture of the information needs and appropriate techniques.

In others, there was evidence of some confusion about the process by which the organization intended to pursue its objectives. Indeed, it appeared that one of the major purposes of the information activities was a search for new processes for achieving the decisionmakers' goals.

Others of the decisionmakers indicated a fundamental lack of comprehension of "producing" anything. Initially, this researcher thought that this was simply a reflection of language difficulties, both between Spanish and Engligh and between an economist and more

normal humans. Careful, but persistent, questioning, however, revealed that a few of the individuals (who did have a significant impact on the design of the information package) fundamentally did not perceive any connection between the activities proposed or the possible resource allocations which might be made and the ostensible social functions. If, for example, the organization's social functions are to provide watershed protection, recreational opportunities, and raw material supply for local industry, and the proposal under consideration relates to substantial changes in land ownership and land-use, then some understanding of the relation between land-use and watershed protection, etc. are required in order to understand information needs. There were a few instances in which the author could not detect any such understanding.

This, of course, reflects much more than a debate about appropriate processes and would require an in-depth study of organizational behavior, which is not our purpose here.

2. Is there agreement about which process is appropriate?

3. Is it necessary that there be?

In none of the examples studied was there complete agreement about the appropriate production process. This disagreement results from both fundamental

disagreement about objectives and disagreement about appropriate processes for achieving common objectives. How this translates into different perceived information needs is evident from the basic model.

4. <u>If they understood only one process, would it be good enough?</u>

In some of the cases, the decisionmakers did have an understanding of the basic productive processes, and this provided a firm foundation on which to build his input to the final design. If the other decisionmakers had systematically worked out an understanding of the productive processes, their ability to identify the needed information, and an appropriate means of deriving that information, it would certainly not have suffered.

D. 1. <u>Do the information systems designers seem to be aware of what current knowledge level the user has?</u>

2. <u>Is there a large difference between the knowledge level of the producer and the user?</u>

In some of the examples, the individuals who produced the information understood quite well what level of knowledge the major user had. In some of these cases, the producer already had, or could easily produce, some of the information needed so the project

was partially the transfer rather than pure production of information.

In other cases, the producer made assumptions about what states of knowledge were currently available (existing data and reports, as well as subjective understanding that might be available) which apparently were not valid. The design errors in this respect, however, were generally not large, although in one instance, the author was able to point out the existence of a highly relevant report which the information program designers were unaware of. Probably the greatest errors in this regard are the frequent assumptions that if no data exists, then no knowledge exists.

E. 1. <u>Is it necessary to define the current state of knowledge in this quantitative way?</u>

There are a number of ways to express a "state of knowledge". The most definitive is through the use of an explicit probability distribution, such as Figure 2 (p. 16). Such a distribution could be based on empirical (sampling) evidence, on subjective estimates, or on some combination of the two. Quantitative solutions to the models require this type of statement. None were made.

Substantially less definitive (but still highly useful) would be some kind of statement with "most

likely value" and "upper and lower" limits. Often it would have been possible to develop subjective probability distributions from such statements. No such estimates existed with regard to the projects studied as far as is known.

Least definitive is an estimate with only an attached statement of "high confidence" or "low confidence". These were often apparent in the nature of the information.

Of all the variables which had been identified as relevant to the productive process of the various example, none could be described as a variable about which nothing was known. Something was known about every identified variable, and in most of the cases, some kind of confidence statement could be made about every item of the set. It appears that no item will be perceived as relevant until some level of knowledge exists about it.

As noted above, if quantitative solutions to the model are desired, it will be necessary to identify a complete set of distributions, even if totally subjective.

2. How can the change in the state of knowledge be indicated in other than this quantitative way?

Changes in states of knowledge per dollar spent

on information generation is, of course, the essence of information economics. Statisticians have long predicted various sampling errors by number of samples to be taken. With estimates of cost per sample, these can be converted directly into the necessary cost functions, such as are illustrated in Figure 3 (p. 23). For items which are investigated through methods other than sampling (by far the majority in the cases studied), these cost functions become somewhat more speculative but not incapable of estimation. Again, if quantitative solutions are desired, estimated functions will be required.

F. 1. Do the impacts flow from the factor proportions?

2. Can they be estimated in some other way?

In the simplistic model which was originally developed, a fixed technology was assumed, and the factor proportions became weights which indicated the relative impacts of the variables to be investigated.

In the examples studied, the productive process was not so clearly or simply defined, and in most cases, a search for appropriate coefficients was an integral part of the information program. The impacts would have to be estimated in a more subjective manner.

G. 1. How closely must we estimate the

cost of information generation functions and the relative impacts?

2. How sensitive is the funding and allocation rationale to errors in estimation of the design parameters?

Generally, funding and allocation decisions were made in these cases without refined estimates of the relative impacts of variables or of the various information levels which could be attained with different expenditures. Thus, little can be deduced from the case studies themselves in regard to how closely the design parameters must be estimated. The results of the computer simulation, presented earlier, offered some insight in this regard.

Summarization of the results of Question V is difficult. In terms of what actually occurred in the cases studied, it is clear that major changes in decisionmaking would be required to implement a quantitative system such as was originally envisioned. The overall decision scheme was so ill-defined as to preclude such an analysis. Objectives were obscure; technologies of achieving the ultimate goals were not understood; there were problems in quantifying existing states of knowledge and of transferring that knowledge; predictions of what one would learn with various expenditures were not made; impacts of remaining ignor-

ance were not quantified. Changes that might be required in decisionmaking to facilitate introduction, changes in the model itself and changes in the outcome of information-generating projects that would result, requires some speculation and will be reserved for the discussion chapter which follows.

Chapter V

DISCUSSION OF RESULTS

Since the writer's initial objective was to suggest, at least conceptually, an analytical scheme for the design and evaluation of information programs, and since the first approximation, as might be expected, was not totally successful, it seems appropriate to discuss the obstacles which have become apparent. The thesis will then conclude with a description of the guidelines which do appear valid and useful.

The first obstacle to the introduction of such an analytical design scheme concerns the reversal of the resource decision process. This was not initially treated by the questionnaire but became implicitly evident in the discussions with the decisionmakers. It

was fundamental to the theoretical models that the information is gathered and the resource allocation decisions were made on that basis, whereas in reality, the decisions were made and then information was gathered to support these decisions. The information models are essentially attempts to get the highest level of precision and the best balance of information for the budget expended. Some of the decisionmakers studied indicated that precise, well-balanced information packages were not what was wanted but rather more convenient data was sought.

This often results from the objectives other than the social functions being pursued coupled with the necessity to publicly justify his activities on the basis of the social function. It may, however, result from nothing more than a poor decisionmaking procedure. If the study of the models does no more than point out these foibles, the effort will have been justified.

A second obstacle is that, under existing conditions, information decisions are not made solely on the basis of achieving the organization's ostensible goals. A variety of other goals are likely to be pursued, often at the expense of the social function. These other goals included both personal and organizational goals. Most of the decisionmakers studied were public officials, but this researcher must agree with

Anthony Downs (1967) when he stated: "Every official is significantly motivated by his own self-interest even when acting in a purely official capacity" (p.262).

One of the organizational goals which appeared to have high priority was the utilization of current capacity. The decisionmakers apparently believed it important that organizations and individuals maintain an image of usefulness. If current skills and equipment could be construed to produce information which was useful, then that information was assigned a high priority. This, of course, is the natural tendency of organizations to maintain themselves.

As might be expected, the second major organizational goal had to do with growth, both "appropriate" and "inappropriate". The distinction between the two is important and difficult. While the economist would attempt to analyze the value of further growth of the organization versus the alternative uses of that capital such measures were not readily available to this researcher nor to the decisionmakers being studied. Two practical management guidelines might be considered, however. One concerns the organization's own assessment of its motivation. If the organization refuses to reveal its motivation for certain growth and maintenance activities, or attempts to cover them up, then it is, by self-definition, probably inappro-

priate. The second approach concerns the openly expressed motivation of organizational growth. If the organization desires to hire more people, purchase new equipment, train personnel, etc., but cannot identify what it will use this increased capability for, then that growth is suspect.

In underdeveloped countries such as those in Central America, it is perhaps reasonable to expect a great deal of effort being devoted to organizational growth and development. And, in the context of natural resource information organizations, the growth is perhaps quite appropriate, even some of that which is nebulous.

Almost all of these diverse elements of motivation were evident in virtually all of the multiple decisionmakers in all of the case studies.

A third obstacle relates to a lack of tradeoffs between multiple goals. That is, even if the design is being done solely in light of the social functions, these social functions are usually multiple, and explicit tradeoffs between them are not easily obtainable.

The theoretical models assumed that organizational goals had been well defined and that tradeoffs between multiple goals were well understood. Numerous references in the literature assume this to be the bas-

is of information systems. Gremmer (1972) lists six essential steps in designing an information system. The first is: "Determine the overall goals of the organization". The need for goal definition does not, of course, emerge uniquely from attempts to design information packages. Keaton (1972), for example, criticizes a lack of priorities between multiple goals for basic resource allocation decisions in the U.S. Forest Service.

These authors (and the theoretical models) appear somewhat naive. The political realities of the organizations studied precluded definitive statements about organizational goals or explicit expressions of tradeoffs between multiple goals. As one respondent stated: "The first rule of guerilla warfare is to never give the enemy a target to shoot at".

Other authors are perhaps more realistic. Haveman (1969), for example, shows that the U.S. Congress cannot, or will not, make specifically stated tradeoffs between multiple objectives. Schultz (1974) outlines similar problems in the Executive branch of our government. Shubik (1967) questions the entire concept of rationality and information in a representative government. In the case studies there was certainly no evidence to indicate that the political organizations of Central America are any more unambiguous about goal

definitions and tradeoffs.

A fourth obstacle concerns the habitual manner in which some information activities are carried out. Often there is never a conscious consideration of why these activities are carried out, but they are simply done as a matter of course. There was no analysis of information needs, relative impacts of various errors or the costs of reducing errors, with regard to some of the activities.

A fifth obstacle is the requirement for a consistent and explicit expression of risk aversion. Although this was only lightly treated in the case studies, there certainly was no reason to discount Friedman's assertion that risk aversion is inconsistently held in operational situations (Friedman, et al., 1948).

All five of these first obstacles are simply characteristics of human beings and their organizations and are far beyond the scope of the present study. They are, in many ways, the underlying causes for the inefficiencies of information projects cited in Chapter I. To permit the focus to rest on these would negate any value which the study may have. Therefore, in the best traditions of economics and systems analysis, they will be ignored until the final conclusions are drawn.

Related to these first five obstacles is the problem of an imperfect knowledge of the social production function. This partially results from a lack of understanding of an existing and known relationship. To the extent that this is the reason for the imperfect knowledge, it will be treated with the first five. This imperfect knowledge can, however, be inherent in the situation and, in fact, may be one of the problems the information generating program is seeking to alleviate. To the extent that this obtains, the proposed scheme is of limited application.

A seventh obstacle is the pluralistic decision scheme which is apparent in information programs of larger magnitude. Although the theoretical models assumed a single decisionmaker, there is no reason why the process could not be carried out by all of those who have an input into the information program design. Thus, the obstacle may be more apparent than real. In fact, the proposed scheme could provide an excellent means of structuring the input from various contributors, thereby facilitating decisionmaking about what factors to investigate and in what depth.

An eighth obstacle to the introduction of such a scheme concerns the lack of a feedback mechanism. The ideal information system would, of course, repeatedly carry out the analytical scheme to determine if suffi-

cient confidence levels have been reached or if internal re-allocations should be made. In fact, such feedback seldom occurs. Even if funding and allocations are completely devoid of feedback, the proposed scheme should be useful in making the initial decisions.

The remaining obstacles concern the actual methods of expressing the design variables themselves and the means of integrating them in such a way as to provide guidelines for decisions about information programs. It is clear that there is less of an obstacle here than was originally foreseen. Decisionmakers in the case studies did appear to recognize that the variables in the models were necessary and sufficient and, on occasion, had some specific estimates of magnitudes. How they were integrated into decision guidelines remains conjectural, but the computer studies lend credence to the assertion that intuitive solutions can be reasonably close to the optimum.

Estimates of the current states of knowledge about the identified variables were not explicitly made in the case studies. There seemed to have been both a propensity to overestimate and to underestimate uncertainty on variables. That is, certain variables were excluded from investigative activities because published data were available even though large errors

were probably involved. In other instances, decisionmakers insisted that no knowledge existed when, in fact, sound estimates could be made immediately or with very little effort. The upper and lower limits of such estimates would be far less than the zero to infinity range which was asserted by the decisionmaker. No special techniques would be required to make these estimates of current states of knowledge.

It appears that many of the decisionmakers recognized that the relative importance of each of the variables ultimately derives from the costs of being wrong about that variable. Indeed, there was some evidence that a variable would not be selected for study unless uncertainty about that variable threatened the achievement of success of the ultimate goal. More explicit expressions of this relative weighting are problematic, however, It is probably unrealistic to foresee explicitly stated social production functions (especially in view of the lack of tradeoffs in multiple objectives). These weights can, however, be directly estimated either with the cited relevance matrix technique or by simple intuitive assignment. No special skills would be required.

Perhaps the most difficult problem in estimating the design parameters will be in regard to the costs of reducing the errors. The predicted reduction in

sampling error per dollar spent on sampling is one approach but is grossly inadequate in most real-world situations. When the additional problems of joint costs, discontinuities, covariations, etc. are imposed, it becomes especially difficult. Nonetheless, there was a willingness on the part of the decisionmakers studied to explore various information generating techniques and sequences of techniques to estimate what might be learned with them. Therefore, it appears that introducing estimates of costs of information generation into the design scheme (even if strictly intuitive) should not be overwhelmingly difficult.

In addition to these obstacles to introduction discussed above it is appropriate here to discuss the attitudinal and philosophical implications of such introduction and what effects the introduction might have on the organizations involved.

First one might ask if the introduction of such design methods implies a change in basic attitudes. If such changes are implied, it is conjectural as to whether they are a result of, or a requirement for, this introduction. The two questions of greatest interest are: (1) the relative importance to the decisionmakers of achieving "hard" results versus having agreeable personal interaction, and (2) not unrelated to the first, his sensitivity to national or regional needs

versus his organizational or personal needs. While it is possible to form some interesting hypothesis from the decisionmakers studied, the results of such explorations would be dangerous and not a little arrogant.

It is sufficient to note that an understanding of such design approaches and attempts at maximizing the results as defined by such achievement-oriented approaches were not a pervasive characteristic of the decisionmakers. Whether it was less prevalent in decisionmakers in the resource agencies studied in Central American than in comparable Anglo organizations, cannot be assessed. The writer's professional experience since completing this research would indicate very little difference.

Next one might ask that, if, as a result of introduction of this approach, changes in basic attitudes were brought about, what would be the effects on overall program. If attitudinal or philosophical changes are associated with a working-level understanding and acceptance of this analytical approach, then substantial internal effects might be predicted. First is the direct effect on internal allocation of effort. In some of the cases studied, there was evidence of a desire to make decisions on the basis of the effects on ultimate social functions, but there was

little understanding of a mechanism to connect the two. This analytical approach provides one such mechanism. This is a direct effect and is not unique evidence of philosophical or attitudinal change. It is possible, however, that if the decisionmakers developed the ability to at least conceptually relate such mundane things as error size and cost estimates for information generation with the ultimate social function, the achievement of the ultimate social function will become a more feasible and meaningful decision criteria. The personal confidence, on the part of the decisionmaker, that he understands the relationships might result in the basic philosophical changes.

These results, if they occurred, would be internal to the project. One might also speculate about the impacts external to the organization. That is, if such analytical design procedures were introduced, what would be the impact on the funding-source, on users and on competitive organizations?

External to the information producer, we might visualize a parallel development on the part of the user and the funding-source. That is, they might have more confidence in what they are asking from the producer and less tendency to accept the design which the producer proposes.

If we assume that acceptance of such a design

approach actually improves performance of the producer (or, more importantly, convinces the funding-source and other control agents that performance is improved), competitive organizations, both functional and allocational, should be put at a disadvantage.

In some of the cases studied, the producer essentially did not have functional competitors. Others of the producing organizations did have functional competitors and, in one case, was a private consultant. In all cases the producers were allocationally competitive with other organizations. Thus, to the extent that the funding-sources are goal-oriented, the improved performance on the part of any of the case study organizations should improve their position vis-a-vis their competitors.

Chapter VI

CONCLUSIONS

It is clear that one can effectively dismiss any idea of building a quantitative model which will optimize the design of information projects in real-world situations. The obstacles discussed in the previous chapter preclude it. It is equally clear that one should not dismiss the theoretical basis on which such a model would rest. There was nothing found in this research to cast doubt on the fundamental soundness of such theoretical bases. Understanding of that theory can serve several useful functions.

It will focus attention on the legitimacy of efforts to design information projects well. It will focus attention on designing information projects in light of the ultimate social objectives of the organi-

zation. Focusing of the designer's attention on the legitimacy of his efforts and focusing his efforts on the ultimate objectives could not help but yield better information projects.

The stressful and wasteful methods whereby the inputs from numerous decisionmakers are integrated into the final design of information projects could be facilitated by an understanding of the theoretical basis. It would provide a method for structuring the pluralistic inputs and for integrating them into the final design of the project.

By using the theoretical basis it would be possible to point out and use the following IF...THEN guidelines.

IF: The basis decisions which the information is designed to facilitate have already been made, THEN the information project is really not necessary.

IF: A variable is less well known than another variable of equal importance and difficulty of investigation, THEN more effort should be put on that variable than others.

IF: A variable has more impact on the achievement of the social function of the organization than do other variables equally well known and equally difficult to investigate, THEN more effort should be put on that variable than on others.

IF: A variable is more difficult to investigate than others which are equally well known and equally important, THEN less effort should be put on that variable than on others.

While these are insultingly self-evident, they are often not used in the design of information programs. If this dissertation is successful in promoting their use in some small way, the efforts of this writer will be justified.

APPENDIX I

Descriptions of Six Case Studies

July, 1972

Description of CETEFOR Highlands Project

The Centro Tecnico de Evaluacion Forestal (CETEFOR), a semi-autonomous agency of the Guatemalan national government, is now beginning a project in the altiplano in the northwestern part of the country. It will constitute the major part of the work of CETEFOR for the next five years. It is a fairly large project with a budget of about $300,000 per year.

The project will be limited to a geographic area consisting of the departments of San Marcos, Quezaltenango, Huehuetenango, Quiche, Solola y Totonicapan. Originally envisioned to encompass a wide range of physical and socio-economic variables, it is now limited to only the land-based variable for the planned development of the area.

Since CETEFOR is not an operational organization (i.e.: it does not execute public works of any kind but limits its activities to information production), it will gather the basic data and formulate plans for resource conservation and development. The execution of the plans will be left to Division Forestal of the Direccion General de Recursos Naturales Renovables.

The altiplano region of Guatemala is heavily populated, very mountainous and largely unsuited to agriculture. The population, mostly decendents of the

Mayans, are very poor, highly traditionalistic and strongly tied to the land. Due to rapid population growth and inflexible agricultural practices, the general landscape is being heavily abused, and the people are getting progressively poorer.

One of the major themes of the current 5-year plan (Rosenthal, 1970) is a search for methods to reverse this trend. Particular emphasis is given to the altiplano, and "one of the most important fields for economic development in the nation is the completion of studies dealing with natural resources".*

In an attempt to implement elements of the 5-year plan, Planificacion Economica issued Memorandum 4-71 (Ramirez, 1971) which requested that the government give priority to a three-point program for the altiplano which was to include community development, rural public health, and natural resource conservation and development. Although generally considered to be poorly conceived, it was declared a priority item, and funds were allocated for its implementation.

The political negotiations which determined which agency got what amount of money were not studied, but CETEFOR received $270,000 for the first year and were given charge of the natural resource conservation and development aspects.

* My translation from Vol. 1, p. 19.

In theory, they were to take overall guidance from Memorandum 4-71 and develop a detailed plan for an action program. In practice, they have been left much to their own devices. Some major reorganization is also planned, so it is presently unclear as to who will implement the plan.

Currently, the planned information activities to provide input for building the action plan include:

(1) Aerial photography of the entire area $70M

(2) Current land use map and land potential map $209M

(3) Forestry studies and demonstration on 5 pilot areas $80M

Other activities are projected up to 10 years, but the outline is very skeletal. Currently they feel the need only to gather information.

The personnel who design the activities and who will administer them are generally well educated with specialization in civil engineering, geography, forestry, and aerial photography.

Although CETEFOR's central social function has to do with natural resource information, it is apparent that the majority of their resources are currently being devoted to organizational growth and development. There appeared to be very little real corruption, how-

ever, and in the context of the current socio-economic situation in Guatemala, such empire building is perhaps appropriate.

Individuals interviewed in studying this project included: Ing. Billeb, CETEFOR; Ing. Carlos Castillo, CETEFOR; Bro. Felix Fournier, Centro de Desarrollo Integral; Dr. Edgar Clark, FAO; Lic. Ramirez, SIECA; Ing. Mario Castillo, CETEFOR; Mr. Bill Binford, USAID; Ing. Gundersen, CONAPLAN; Ing. Luna, Direccion General de Recursos Naturales Renovables.

Description of Talamanca Forest Reserve Feasibility Study

In late 1971, the Direccion General Forestal in the Ministerio de Agricultura y Ganaderia de Costa Rica conducted an ad hoc study to determine the feasibility of establishing a forest reserve in the Talamanaca Mountains. The study was conducted by the Departmento de Investigaciones Forestales, one of four departments in the Direccion. It was designed and managed by the Chief of Forestry Investigations.

The major purpose of the study, in addition to spelling out what was proposed, was to describe the physical and cultural character of the area and to estimate the cost of establishment.

In the process of the study, the following resources were used:

- 30 days of professional forester's time
- 60 days of a technician's time
- 30 days of a topographer's time
- A complete set of aerial photography which was supplied without cost to the Direccion by the Ministerio de Transportes

No field work was done.

The output of the study was a formal report and a proposed decree as well as more general organizational

familiarity with the area. Promotional activities which followed the study indicated that the latter was very important.

The user, to which the report was addressed, was the Minister, who would, in turn, use it to get the President or the Congress to establish the reserve. Their overall objective in this regard could be regarded as general conservation or, more specifically, to ameliorate the flooding that seems to originate in the Talamanca Mountains, to avoid loss of on-site productivity from inappropriate land-use, to conserve recreational opportunities, and to promote tourism.

To the extent that the overall objectives of the Direccion General Forestal coincide with the objectives of the Minister and Congress, those listed above are also the ultimate objectives of the information producer. It is apparent, however, that a more fundamental objective of the information producer was to increase their power and influence at the expense of another government agency--the colonization institute which currently had authority over the land. Thus, the objectives of the information producer and the information user do not totally agree.

After all the interviewing and documentation study was completed and summarized for this case study, the researcher still felt some vague uneasiness that some

significant motivation for the feasibility study had not been treated. After some intense questioning, the designer and manager of the feasibility study revealed that MAG had run out of money at the end of 1971, so there were no funds to allow any transportation or other expenses. Everyone was restricted to the office in the capital. While allocation of available manpower, etc. continued on some maximizing basis, the possibilities for productive use was constrained, not by total manpower or budget, but by manpower that had the capability to generate information without going on the ground. Thus, in some respects, it could be viewed as a "make-work" project until more gasoline could be bought.

Individuals interviewed in studying this project included: Ing. Madriz, Direccion General Forestal; Dr. Joe Tosi, Tropical Science Center; Ing. Rodrigo Gonzales M., Depto. de Investigaciones Forestales.

Description of the Guatemala Forestry Statistics Program

The Division Forestal of the Direccion General de Recursos Naturales Renovables in the Guatemala government has a regular continuing program which gathers nation-wide forestry statistics. The program was designed and is operated by a single forestry technician with the assistance of one or two clerical personnel.

The program, which has now been in operation two years, has, as its major information output, an annual report (see, Anon., 1971) which currently treats only the physical output of the local forest industries.

The total funding for the program consists of only the salary items plus a modicum of supplies and office overhead plus some travel expenses. The internal allocation of these resources expended between the several possible information items is left up to the individual in charge. That individual also determined the techniques used for generation and compilation, as well as format of output.

Since the interest is currently limited to physical output of industry, the techniques in the project are fairly simple. A monthly questionnaire is sent to all registered sawmills, the single plywood mill, the particle-board plant, impregnation plants, and other minor industrial wood users. An attempt is made to collect

fuelwood drain statistics by a roadside counting method. The returns are compiled and published in a 25-page annual report which estimates receipts of roundwood, the throughput of the manufacturing facilities, and the foreign and domestic sales volumes.

Generally, the techniques used and the output produced are very poor. Gross errors are evident in the compilation procedures, poor response rates occur with the monthly questionnaire, and the partial coverage is not clearly indicated. Choice of variables is not well thought out, and the ultimate output is, for almost any conceivable use, virtually worthless.

This researcher, as part of the necessary effort to gain rapport with the project personnel, and at their request, did a critique of the techniques used to produce and present the information currently of interest. He supplied numerous corrections and suggestions which, if followed, should improve the efficiency with which the information is produced and the value of the output. The choice of what to produce, however, was not disturbed, since that was one of the major objects of study.

A professional forester from within the Division Forestal is currently away on a "beca", learning statistics in order to upgrade the program.

Individuals interviewed in studying this project

included: Agro. Hector Vasquez C., Direccion General de Recursos Naturales Renovables; Mr. Thomas McKenzie, IICA; Ing. Luna, Direccion General de Recursos Naturales Renovables.

Description of the Forestry Chapter of PACA

The General Secretariat of the Central American Common Market (SIECA) has a FAO (Food and Agricultural Organization of the United Nations) advisory group attached to it, which supplies technical expertise for the planning and integration activities carried on by the Common Market. This advisory group (called GAFICA for its Spanish acronym, Grupo Assessor de la FAO para la Integacion de Centro America) has spent a major portion of its effort for the last two and a half years preparing a Plan Perspectivo para el Desarrollo y la Integracion de la Agricultura en Centro America (PACA). Part of this perspective plan was to deal with forestry in all five countries of the Common Market.

Although the planning exercise encompassed more than straight information generation, a majority of the total resources expended were devoted to either the generation of new information or the compilation of old information. Thus, a substantial amount of identifiable decisionmaking took place with regard to the information generation activities for the forestry chapter. An attempt was made to analyze it.

At the time the analysis took place, GAFICA had rejected a completed forestry chapter which had been submitted by a consultant, and they were in search of

another consultant to re-do it.

The consultant, whose general terms of reference were "to analyze future prospects for forestry development in Central America and prepare a draft forestry chapter (or chapters) of PACA...", was a FAO forester assigned to an advisory group in Santiago de Chile. He spent several months working on this chapter but was not successful in supplying the desired output. His lack of success, however, apparently was due to what he did with the information rather than what information he gathered. GAFICA is a strong advocate of sectoral planning. Although the consultant gathered much of the information needed for sectoral planning, he did not develop it into a comprehensive sectoral plan which was satisfactory to GAFICA.

In this case, the funding-source and the producer were both FAO, although the consultant was paid from his own group in Santiago rather than from GAFICA. The user was conceived of to be both SIECA and, in the member countries, the professional planners at the Ministry level.

The techniques which the consultant used were largely ad hoc procedures. Previous studies (McKenzie, 1971; Plath, 1965; Gregersen, 1969) supplied much of the basic data, although he spent considerable time travelling within the five countries, gathering addi-

tional industrial production data, as well as compiling information on forestry sector plans in the individual countries. After compiling the information into 11 appendices, totaling 157 pages, he developed a perspective plan for the forestry sector. The perspective plan was the focus of the discontent. The consultant, it was felt, did not adapt the basic objectives of PACA, which were very broad and comprehensive social development (i.e.: income distribution, labor absorption, foreign exchange, etc., as well as GVA). Instead, he addressed the problem of investment feasibility almost to the exclusion of the others. Thus, GAFICA felt that the report could not be integrated into PACA in its form at that time.

It is interesting to note that the discontent which GAFICA had with the consultant's output was focused almost solely on what he did with the information that he presented rather than the information itself. In fact, their critique of his work concludes that "...a clear definition of objectives and a strategy for forestry development in Central America would permit the re-writing of the text, utilizing conveniently the excellent technical material found in the annexes."*

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* My translation from: Comentarios sobre el informe relativo al sector forestal. GAFICA. November 1971. 8 pp.

In terms of an analysis of the information generation, this leads to four possibilities:

(1) The information needs (both in total and in terms of internal balancing), for the investment feasibility study which was done, happen to coincide with those of a broader perspective development study which was desired.

(2) GAFICA did not have a refined understanding of the information needed for such a perspective plan (or at least did not express it in their critique).

(3) The consultant did not gather information that was ideally suited for the investment type study which he did, but instead gathered information which was appropriate for the perspective planning which, in final analysis, he did not carry out.

(4) The information needs for sectoral planning do not play a determining role in its success.

All of the above undoubtedly hold some validity in this case. There <u>is</u> much in common between the two sets of information needs. GAFICA did not do a refined analysis of the information presented, only an analysis of what was done with the information. Conversely, the consultant, who was not totally conversant with, nor an advocate for, sectoral planning, recognized that, in order to "play the game", he would have to treat some of the broader social aspects and, in the information

generation phase, gathered appropriate information. Some of this kind of information does appear in the appendices but is not used in the body of the report.

The fourth possibility is of particular note. One of GAFICA's avowed objectives is methodological development for sectoral planning. This methodology is in such a state of flux that concise definition of information needs and "fine tuning" of information systems for satisfying these information needs is impossible.

Individuals interviewed in studying this project included: Dr. Van As, GAFICA; Dr. Valensuela, GAFICA; Mr. Thomas McKenzie, IICA; Dr. Sebald Manger C., GAFICA.

Description of the Guatemala-NASA Project

The Instituto Geografico Nacional de Guatemala (IGN) has a project with the ERTS program in NASA, which has two purposes. They are: "(1) Assess the utility of ERTS imagery for up-dating resource and land-use data in addressing complex problems of soil erosion, agricultural deficit, deforestation, and floods. (2) Demonstrate utility of ERTS imagery for extrapolation of geologic mapping beyond areas mapped in detail, and for tectonic structure delineation." (Secretaria General del Consejo Nacional de Planificacion Economica, et al., 1971).

While the national planning body is the official representative, the principal investigator (and initiator) is a young hydrologist in the geographic institute (IGN). IGN is a highly-regarded, nationwide, semi-autonomous institute whose major activity is information production, largely in the form of maps. It has no on-the-ground, public-works programs.

The geographical areas to be treated are two large areas in Guatemala plus the adjacent offshore areas. The subjects to be treated are only limited by the purposes quoted above and, as careful study will reveal, cover virtually any conceivable natural resource.

The immediate activities envisioned include the

compilation of a cover-type map for the areas covered, "verification" of existing geologic maps, and study of offshore currents.

The ERTS-A satellite, which was scheduled for launch in mid-1972, was to provide the core input of the project. Various types of imagery were to be supplied by NASA to IGN which will provide all interpretation, ancillary imagery, and preparation of information output.

Planificacion Economica, whose operational objectives are to compile and execute the five-year development plans (e.g. Rosenthal, 1970), is conceived of as the principle user of the information.

The characteristics of the information output are not well defined at this time. Since this project is somewhat exploratory, the output will depend on the capability of the system.

Funding of the project is from two sources. NASA will provide the imagery without cost to IGN. The costs of the space imagery interpretation, ancillary information generation, and output preparation will be borne by the Government of Guatemala. Although Planificacion Economica has agreed to the extra funding necessary (and has already increased IGN's authorization a small amount), it is doubtful that they recognize the total budget that will be required.

The project, therefore, is somewhat exploratory but is not a reconnaissance. They do not know what information they will get for each internal dollar spent, nor do they have a firm command of what the information needs are. The project is largely aimed at answering those questions.

Individuals interviewed in studying this project included: Ing. Gundersen, CONAPLAN; Dr. Luis Garcia, IGN; Ing. Marco Antonio Curley, Direccion General de Recursos Naturales Renovables.

Description of the Guatapé Ecological Reconnaisance

This case study concerned an information project done by a private consultant for a semi-public power company in the spring of 1972. The consultant is located in Costa Rica, but the project was carried out in the area of operation of the power company in NW Colombia. It was done on rather short notice and consumed only about 45 man-days.

The consultant received a fixed fee plus his travel and miscellaneous expenses. The power company also expended a good deal of middle-level manpower providing logistic support for the consultant as well as executive time in discussion with him.

Although the power company was the contractor, the World Bank (IBRD) apparently was the major initiating force. The power company was negotiating for a loan to expand hydroelectric facilities in the area, and, as a condition for granting the loan, IBRD required the report written by the consultant. IBRD paid the portion of the total expenses which required foreign exchange, and received the first copy of the consultant's report. The subject of the report, however, dealt with management practices of the power company. Thus, it is difficult to define who was the user and who was the funding-source.

The information package was called an ecological reconnaissance. It dealt largely with the land resources in the area of a new and fairly large reservoir and the impact of the resevoir on the land-use patterns and the reciprocal impact of the changing land-use on the reservoir and the attendent facilities. Specifically, it was to treat the biotic community, scenic and aesthetic qualities, the agricultural and forestry impacts, some community relocation problems, and other ecological impacts which were apparent.

It appears that the major motivation for developing the information package was to avoid catastrophic losses to the power project directly and adverse political reaction which might occur if the power project resulted in undesirable social impacts.

Given the sharply limited resources available to produce the information, it is evident that no more than the search for possible catastrophic losses could be expected. No such possibilities were identified as extremely ominous, although the consultant pointed out a number of avenues for improved management, both in terms of organization and practices.

The techniques used to produce the information were largely limited to three: (1) a ten-day field excursion to the area for discussion and direct observation, (2) The study of a wide variety of existing docu-

ments relating to the project and, (3) a significant measure of personal experience, both in that specific geographic area and in similar (climatically, topographically, and culturally) areas.

While the total budget, in terms of time and money, was arbitrarily fixed at the onset, and general "terms of reference" placed some broad limits of the subjects to be treated, the consultant was fairly free as to his internal allocation of effort. How he made that was the major subject of study during interviews in Costa Rica. Upon return to the U.S., an effort was made to ascertain from the IBRD the overall funding rationale.

Individuals contacted while studying this project included: Dr. Joe Tosi, Tropical Science Center (a private consulting group); Mr. E. Friedman, World Bank; Ing. Alvaro Villegas, Empressas Publicas de Medellin.

APPENDIX II

Questionnaire Used in Field Studies

QUESTIONNAIRE RELATIVE TO THE DESIGN OF INFORMATION PROGRAMS

General

- Is this information program designed for your own control purposes? If so, can we talk about a comprehensive "package"?

- If it is not for your control purposes, who is the client? Are there other users besides the client? Who will ultimately pay the bill?

- Is the user simultaneously getting information from other sources which will be collated with this to make decisions?

- Can the decisions be fairly characterized as resource allocation decisions? Better term?

- Who decided the content of the program? Were there advisors?

- Are there non-budgetary constraints on the type of information which can be gathered? Statutory? Political? Technical? Other?

- Is the program seen as producing information for short-run ad hoc decisions or for longer run management decisions? If both, could the program have been justified on the basis of only one? What is the relative balance?

- During the design stage, and in terms of total resources devoted to the information program, how would you divide the activities between:

Activity	Percent of total resources
(a) Collection of old data and conversion to common basis-	
(b) Generation of new data-	
(c) Manipulation and analysis-	
(d) Formulation of policy proposals-	
(e) Presentation of findings-	
	100%

- For activities (a) and (b) above, is the reduction of uncertainty the only motivation? If not, what other?

- How do you estimate the amount of uncertainty the user can tolerate? The producer? Third parties?

Objectives of the Information User and the Information Producer

If the user is unique and cleanly identified:

- What is the nature of the user's "productive process"? What are his inputs, outputs, and technology?

- During the useful life of the information produced, are significant changes seen in this productive process?

If there are a number of users:

- Who are the users and what are their relative importance?

- What factors are common between their productive processes? Are the relative weights within their productive processes equal?

If the user is only vaguely known or does not presently exist, but is hoped to exist in the future:

- What is the process of deducing his information needs?

If the user is unknown or does not presently exist:

- What is the motivation for the program of information generation?

If the producer and the user are not the same:

- Who else is producing information for the user? How do you assess the appropriateness of this activity? Is there overlap or missing information?

- Do you feel that you understand the productive process of the user well enough to design an information package appropriate to it?

- If the user had designed his own program, do you think it would have been different from the one you designed (or would have designed)?

- Do the objectives of the information producer include things other than immediate satisfaction of an information need? (e.g. personnel training and organization building, promotion of future

business, obtaining inside information for third purpose, etc.)

Choice of Variables

- How did you choose the variables to be studied?

- How are the variables related to the productive process? Are they directly estimated inputs? Outputs? Proxy variables for inputs or outputs? Estimates of production coefficients?

- At the time of project design, did your perception include factors which were an important part of the productive process, were not well known, and were not part of the information program? Does the design include factors that are not related directly to the productive process?

If the project is complete or near complete:

- During the project, did you discover new variables which seem important? Would you now choose new variables or different methods of learning about them?

- During the project, did you discover that some of the variables thought to be important and not well known, were, in fact, sufficiently well known or were unimportant?

Estimate of State of Knowledge or Current Error

- How did you assess the usefulness of the old information which was available? Please check (or rank) which of the following are relevant criteria:

  - Purpose of the production of old information.
  - Reputation of producer.
  - Methods used by producer to acquire old information.
  - Method of presentation.
  - Data and statistical analysis presented in support of report.
  - Direction from outside source to accept or reject old information.
  - Other?

- Was any of this old information used directly, adapted, updated, or converted? How?

- If not, did it provide a valuable planning input for design of new information generation? In what way?

- It has been said that, on occasion, it is cheaper or faster or easier or better to re-invent old information than to retrieve it. Do you believe this to be valid? Is this project an example? How would you assess the relative costs?

If all work or all work on some variables is totally new:

- How do you assess the current point and error estimates? Were these implicitly or explicitly used in the design of the project?

Impact or Relation of Errors to Productive Process

- Was this "relative impact" used in the design of the project?

- At the time of design, and with those current point and error estimates, what was the relative impact of errors in the several variables on the outcome of the productive process?

- Can this relative impact be reduced to some measurable form? If not, could they be ranked?

If the project is complete or near complete:

- During the course of the project, has your perception of the relative impact of the several variables changed significantly? If yes, was it due to:

  - Changes in the current point or error estimate.
  - Changes in the perceived production process.
  - Other?

Cost of Reducing Errors

- Given the point and error estimates at the time of design, were cost estimates made for reducing the errors by various amounts? If yes, are they available? If no, could they have been?

- For variables which are not well described by point and error estimates, how do you estimate costs? Figures available?

- What was the costing procedure?

    - The project was designed and then costed.
    - A budget was set and then it was designed.
    - Sequential approximations of costs and design.
    - Simultaneous integration of costs and impacts.
    - Other?

- For the several variables: In what units were the cost estimates made? Were there separate estimates made for labor, equipment, etc.? How was overhead costed?

- Are there pronounced economies of scale with some of the variables? Are there agglomeration economies? Important discontinuities?

Summary

- Is there another theoretical way to provide a rational design of these projects?

- If an easy-to-use but highly analytical method were available for designing these projects, would it be used?

If the project is complete:

- To what extent is the output of this project being used in decision-making?

If the project is not complete:

- How do you assess the liklihood that the information and analysis produced by this project will be used in decision-making?

APPENDIX III
Decision Game

INFORMATION GENERATION DECISION GAME

You have some capital to invest (say $100,000). A trusted friend approaches you with an offer to sell to you a sawmill which is operational and has some attached timberland. It is currently being operated by three brothers who are the owners and who do not pay themselves any wages.

You are familiar with the business and think that the offered price of $85,000 is perhaps reasonable. After one day of on-the-ground investigation (cost of your time: $100), you think that there are only three factors about which there is sufficient risk to consider spending money on further investigation before deciding to invest or not.

These three factors are:

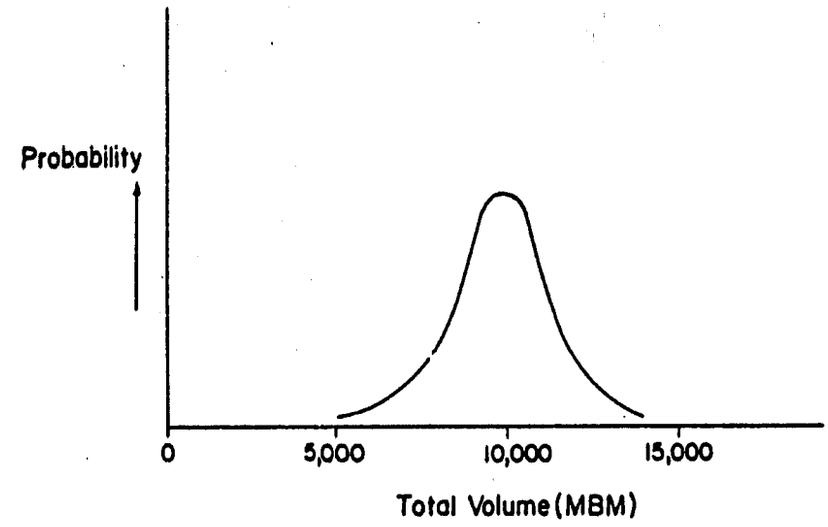
(1) The volume of timber attached to the mill and which will be included in the package deal.

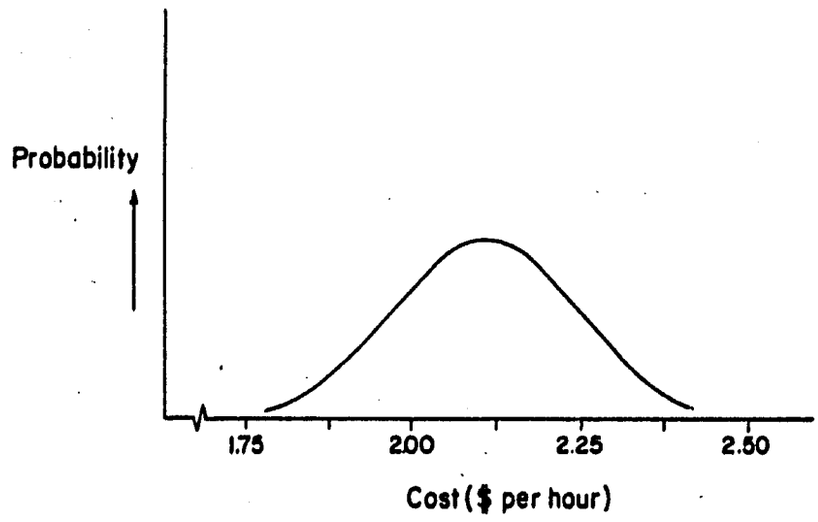
(2) The cost per hour of the labor that will be needed to operate the mill.

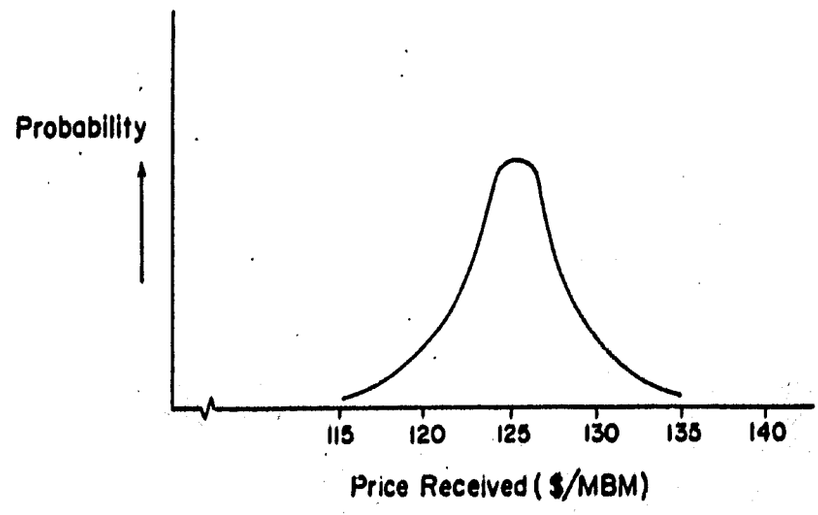
(3) The price you will receive for the output of the mill.

After some thought, you estimate that the true values of the three factors might have the following

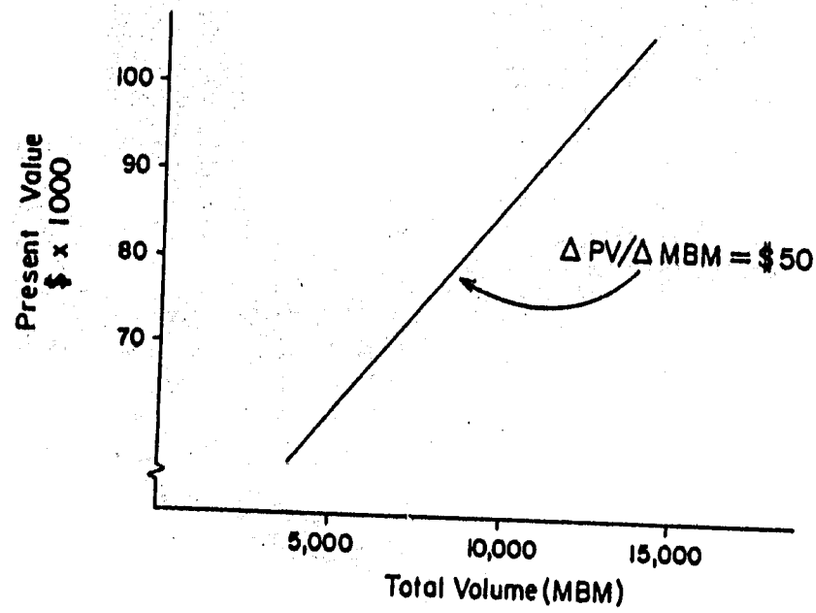
probabilities of occurrence:

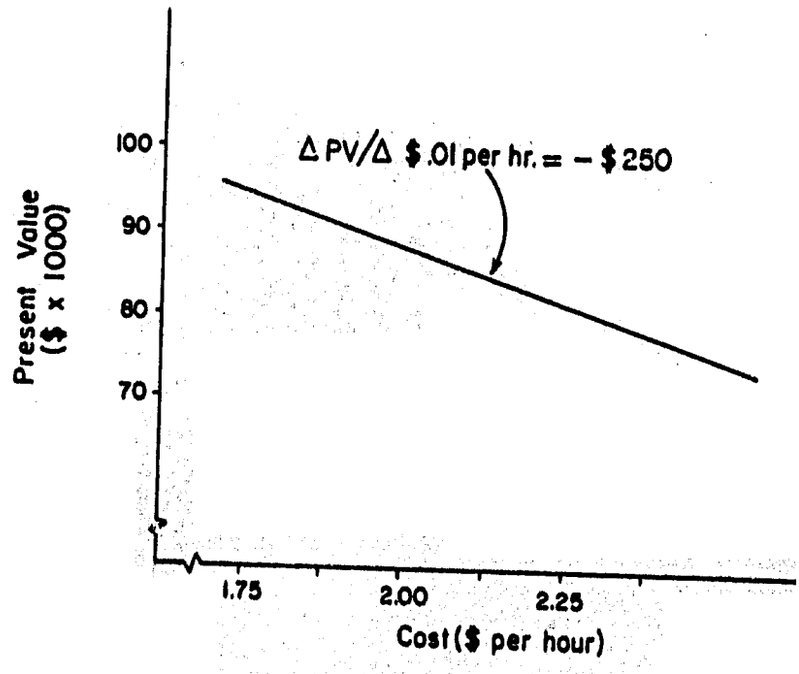


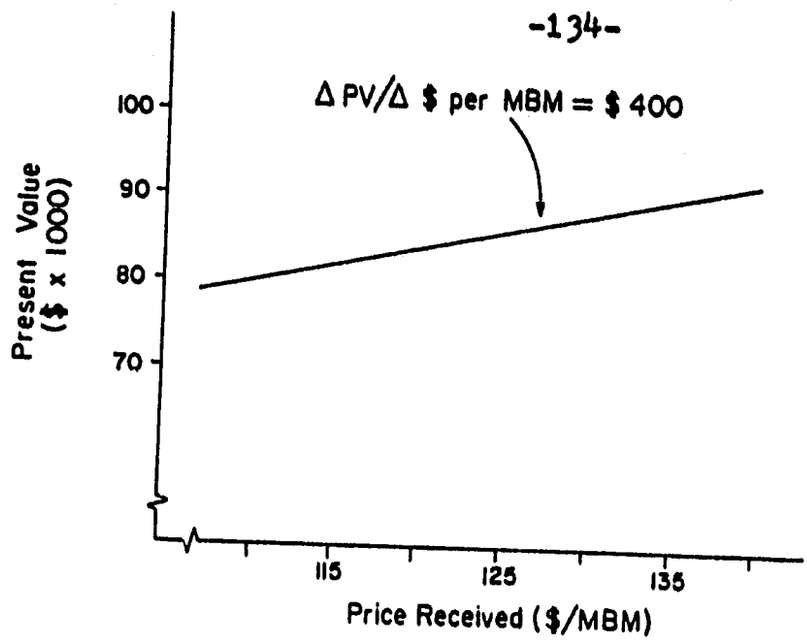




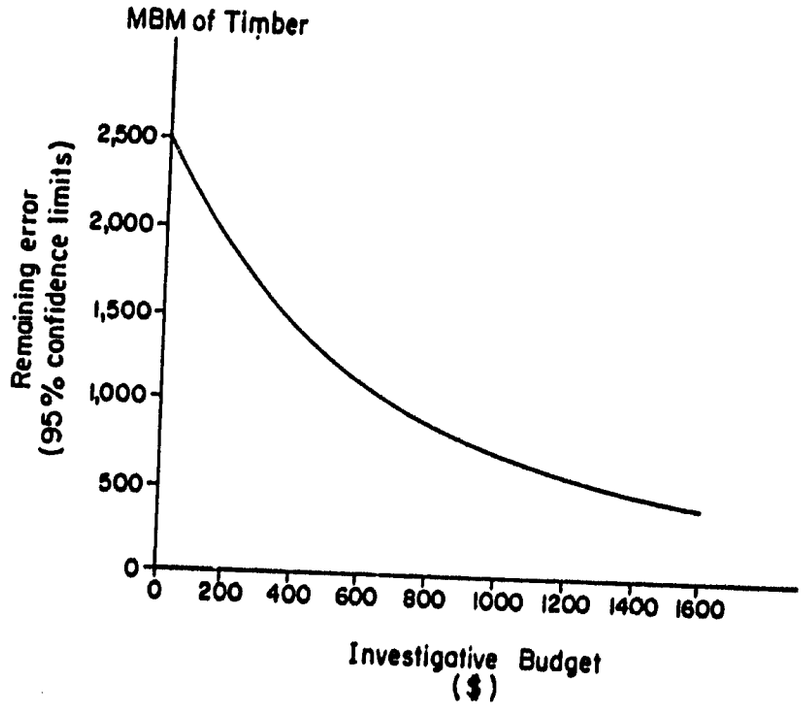
Given your experience in the business and reasonable estimates of the other factors (which you are relatively certain about), you think that the profitability when capitalized into present value might vary over the following ranges with the three factors:

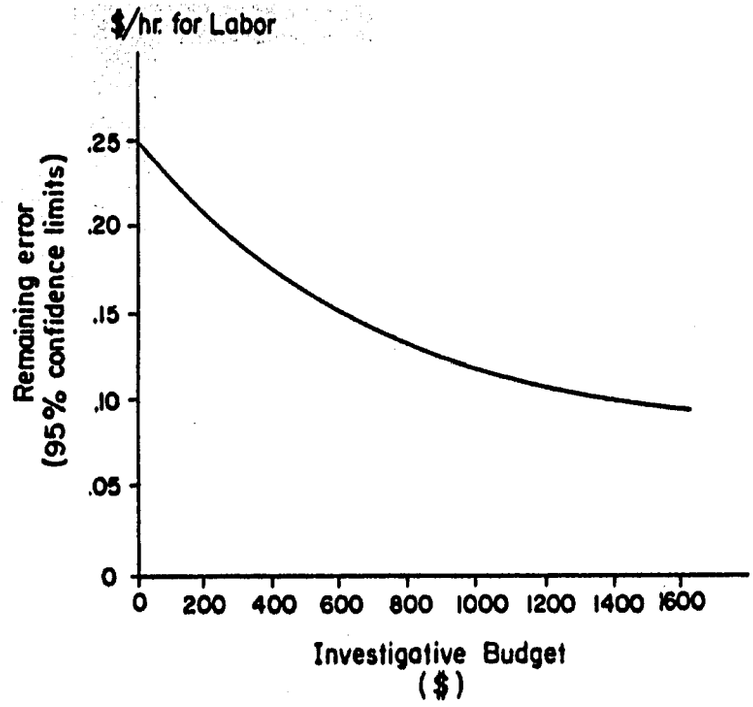


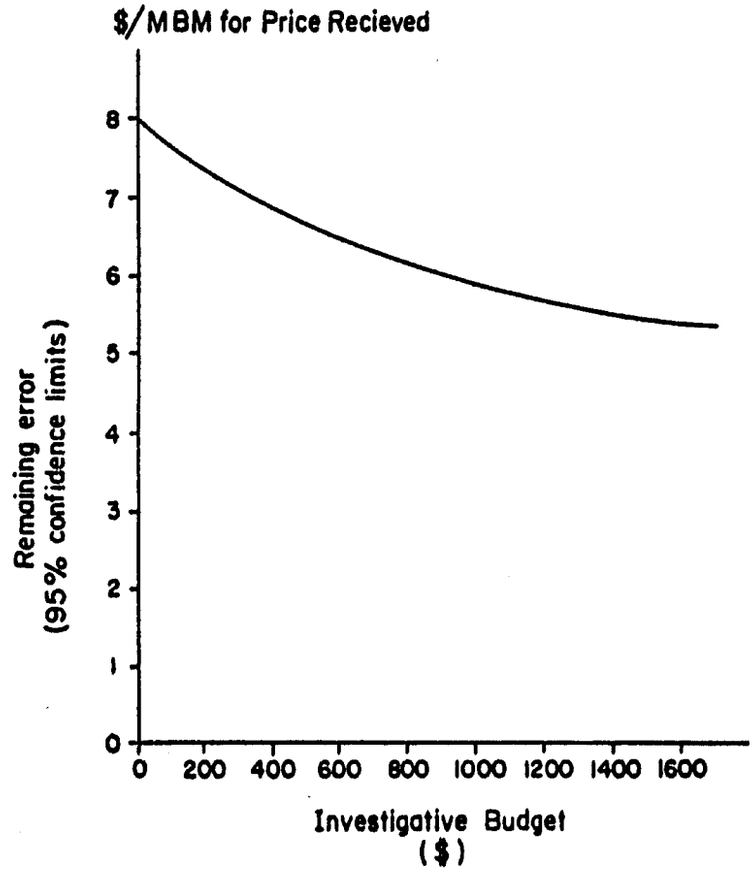




Since you also know something about the procedures of cost estimating, timber cruising, and market studies, you have some estimates of what it will cost to increase your certainty about the three factors. These "error reduction" functions are estimated as follows:




$/hr. for Labor
Remaining error
(95% confidence limits)
.25
.20
.15
.10
.05
0
0
200
400
600
800
1000
1200
1400
1600
Investigative Budget
($)


$/MBM for Price Recieved
Remaining error
(95% confidence limits)
8
7
6
5
4
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
Investigative Budget
($)

How many more days or fractions thereof (at $100/day) would you spend investigating, and how would you divide the time between the three factors?

Total days: _____

Days devoted to timber volume estimation: _____

Days devoted to labor cost estimation: _____

Days devoted to price estimation: _____

INFORMATION GENERATION DECISION GAME

OPTIMUM ALLOCATION OF THE FOLLOWING BUDGETS ARE:

TOTAL BUDGET (DOLLARS)	ALLOCATED TO F(1)	ALLOCATED TO F(2)	ALLOCATED TO F(3)
200	162.649	37.3506	0
400	310.325	89.6754	0
600	447.629	152.371	0
800	577.453	222.547	0
1000	701.707	298.293	0
1200	821.699	378.301	0
1400	938.358	461.642	0
1600	1052.36	547.637	0
1800	1164.22	635.781	0
2000	1274.31	725.69	0
2200	1345.77	795.111	59.1166
2400	1404.28	857.153	138.566

IF THE ALLOCATIONS SUGGESTED ABOVE ARE FOLLOWED, THE BEST ESTIMATE OF THE RESULTS WILL BE:

TOTAL BUDGET (DOLLARS)	PREDICTED OVERALL ERROR AT 95 PERCENT CONF. LEVEL	PREDICTED ERROR ON F(1)	PREDICTED ERROR ON F(2)	PREDICTED ERROR ON F(3)
200	12148.8	201.263	24.0285	8.
400	10539.6	165.504	22.7556	8.
600	9300.51	138.202	21.358	8.
800	8318.6	116.776	19.947	8.
1000	7527.37	99.6386	18.5911	8.
1200	6884.41	85.7509	17.3307	8.
1400	6360.46	74.3983	16.1878	8.
1600	5933.9	65.0698	15.1715	8.
1800	5587.78	57.3866	14.283	8.
2000	5308.27	51.0594	13.5175	8.
2200	5077.24	47.5313	13.0122	7.72493
2400	4872.11	44.9489	12.617	7.38968

CP 0.477 SECS.

RUN COMPLETE.

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