Chapter 4

DEVELOPING A MODEL

The development of a theoretical approach to an issue as complex as the elimination of the lung cancer epidemic among uranium miners is fraught with difficulty. Only the human ecologists seem to have undertaken theoretical explanations with regard to issues so complex. While their approach ultimately proves more stimulating than useful, it is only proper to pay them homage. In the present context, their most useful conceptual tool is the "ecosystem," along with its component categories: population, organization, environment and technology.[63] As Duncan puts it:

> These categories, population, organization, environment and technology (P,O,E,T), provide a somewhat arbitrary simplified way of identifying clusters of relationships in a preliminary description of ecosystem processes. The description is, by design, so biased as to indicate how the human elements in the ecosystem appear as foci of these processes. (64)

In terms of the conceptual scheme of the ecological complex, the problem of official delay in the reduction of excess radiation in mines becomes more understandable. Underground miners were exposed to radioactive emissions from uranium rock (E→P)[65] which were believed to impair health. In response to this situation, certain health officials appealed to business and government leaders (O⟶O) to control underground radiation levels (O→E). Technology to reduce radiation has been developed to handle the problem in Europe decades earlier (O→T) and was available for adoption by American mining companies (T→E) at an extra expense (O→T). However, because of the strong need for uranium for the domestic weapons program, (E→T) the unstable and transient character of the industry which made it difficult to supervise by government agencies (O→O) and the absence of immediate evidence that biological harm was occurring to underground miners as a result of their exposure to uranium ore (E→P), officials were not convinced that the situation merited regulation (O→E). Subsequently, economic and political considerations shifted. The government accumulated a uranium surplus and no longer required additional reserves (E⟶O). The industry became successively more stable and large scale and subject to government overview (O→O). Moreover, evidence accrued demonstrating that miners were dying of lung cancers at elevated rates (E⟶P). Finally, government enforcement agencies issued regulations covering radiation levels in underground mines (O→E). As a result, companies installed ventilation technologies that reduced or eliminated underground radiation altogether (O,T→E). This diminished the hazards of mining uranium and disease rates among uranium miners are expected to exhibit parallel declines (T→P).

In this framework, the resolution of the problem involved an intricate interaction of factors in the ecological complex (P,O,T→E). Environmental modification and social change were systematically interrelated. Any less elaborate scheme could hardly handle the interrelations of the variety of variables which featured in the reduction of radiation in mines to tolerable levels.

But for actual research purposes such an approach provides insufficient guidance. Therefore a more modest approach has been adopted. It draws upon and modifies some of the more established conceptual ideas utilized in research on complex organizations.

This approach treats the solution of the lung cancer epidemic among uranium miners, documented briefly in Chapter 2, supra, as a historical process. The actors in the process are, of course, organizational actors--regulatory agencies, companies and unions. Their problem-solving behavior will be examined in terms of the ways in which it was shaped by historical factors and interorganizational influence.

Analytically, the key concepts in the above statement of the approach are those underscored: historical process, historical factors and inter-organizational influence. A brief discussion of each is in order.

That the solution of social or technological problems occurs to greater or lesser extent as historical process may seem merely definitional. In this analysis, however, statement of the truism permits distinction of some conceptual significance. For the historical process by which a social problem (e.g., a lung cancer epidemic among uranium miners) is solved by organizational actors embodies two distinct stages. The first stage involves designation of the solution of the problem as an organizational goal. In the language employed in the study of complex organizations, this refers to organizational goal-formulation. An organizational goal in this sense is what Etzioni has called " . . . a desired state of affairs which the organization attempts to realize."[66] The goal-formulation stage in the present case was, of course, the stage at which the organizational actors adopted policies designed to eradicate lung cancer in the mines. The distinct second stage, once an organization has formulated a goal, is carrying out the goal; or, again borrowing from Etzioni, becoming "effective" in realizing the goal.

The importance of the distinction between the goal-formulation and the goal-realization stages is best illustrated by an example of what happens when the distinction is ignored. One body of sociological literature on problem-solving tends to do just that; it ignores the goal-formulation stage and concentrates exclusively on the realization stage.[67] It asserts that the prerequisite for the solution of any social problem is information about the problem coupled with technology to solve it in the hands of appropriate decision makers. With such a view, one might expect that once scientists knew about the cause-and-effect relationship between lung cancer and exposure to radiation, and once they conveyed such information to industry and government leaders, and once these leaders possessed the technology to reduce radiation in the mines . . . steps would have been taken at once to bring the problem under control.

Such, however, was not the case. The record shows that from the very outset medical evidence from the European experience of the early part of the twentieth century was widely available; it strongly suggested radiation in mines was harmful to workers. Technology to solve the problem was also available from the start. Moreover, information was published and available showing that the costs of providing adequate ventilation were a mere fraction of the operating expenses of mines which were unventilated.

The discrepancy between what might be expected on the basis of the literature and what actually occurred lies in the failure to distinguish between the goal-formulation and goal realization stages of the problem-solving process. In the latter stage, goal-realization, the presence or absence of relevant technical information and technology is obviously critical. But in the first stage, that of goal-formulation, such information and technology may be altogether irrelevant. Records show that in the late 1940's and the 1950's a climate of indifference to the known biological consequences of mining uranium prevailed. In this climate, research findings attributing lung cancer to exposure to radiation met with official disbelief. The disbelief was not occasioned entirely by the quality of the research findings, because later equivalent findings were used to establish the official regulations which ultimately brought the uranium hazard under control.

The real difference lay in the level of concern of officials in organizations at different points of time. When concern was low, the cause-and-effect relationship between radiation and cancer was regarded with skepticism. Once concern was aroused, the relationship was taken seriously. This tendency is aptly expressed by one interviewee in response to questions on the technology needed to control radiation in mines:

> The technology has always been around. We've always had fans. The interest, however, only came about in the mid-1960's and this caused the big change. (68)

In the analysis of the goal-formulation stage, then, the question seems to become one of identifying factors <u>other than</u> information or technology which generated interest, or as it will be referred to later, "organizational concern."

When the solution of the lung cancer epidemic in the mines is conceptualized as a two-stage historical process, it becomes important to examine the nature of the constraints to which each stage was subject. In the approach adopted here, these constraints are categorized as <u>historical factors</u> and <u>interorganizational influence</u>.

The concept of historical factors as used here comes very close to what has perhaps more commonly been designated as the "organizational environment."[69] It flags the obvious but important idea that organizational problem-solving does not occur in a vacuum--neither in its goal-formulation nor its goal-realization stages. A variety of influences to and often beyond the control of the organizational actors (in addition to

the influence of other organizations) affects their behavior throughout the problems-solving process. Such external factors include forces which are, broadly speaking: economic,[70] technological,[71] political,[72] and legal, among others. In the course of the study, specific manifestations of so-called historical factors will be examined in detail; in the conclusion an attempt will be made to show some of them represent generic forces at work in any historical process of organizational problem-solving.

The concept of interorganizational influence emphasizes that organizations acting as to a common problem act upon each other as well as upon the particular problem sought to be solved. Organizations influence each other's behavior. Just what such influences may be in a given case, let alone how they operate, is exceedingly difficult to specify. The study of formal organizations seems not to have gotten much beyond the stage of recognizing, in theory, that such interorganizational influence is important.[73] In point is Evan's notion of the "organizational set,"[74] but the utility of such a notion is uncertain in a research context such as that involved here where there may be no single "focal" organization in the field of organizational action. Norton Long has verbalized a similar idea in his phrase, "ecology of games,"[75] although he leaves the concept pretty much as he finds it on its connotative feet. Studies such as David Roger's of the New York City Department of Education[76] have purported to take up Long's notion without significantly refining or advancing it. Only Philip Selznick's study of the T.V.A. comes close to fitting the examination of interorganizational influence into a larger theoretical framework. In so doing it elaborates one type of interorganizational influence, co-optation, and shows how it operated to alter the character of the T.V.A. and its attendant policies.[77]

It will be possible in this study to specify in some detail the process by which organizational actors affect each other's formulation of goals and, at a later stage, each other's realization of those goals. In the context of organizational problem-solving, it may also be possible to state some generalizations about the process.

Having outlined a perspective designed to conceptualize the process of solving the problem of excess radiation in mines, we now turn to the actual research scheme employed.

THE STUDY DESIGN

In light of the approach adopted, initial objectives were twofold: first, to identify the actions or events that managed to arouse the concern of officials in organizations with the power to do something about the hazard (goal-formulation stage); and second, to identify the various ways in which official organizational concern, once aroused, was translated into action to reduce the hazard (goal-realization).

These objectives were met in the course of detailed historical research. The activities of organizations involved with the problem were

studied over a twenty year period, though often earlier records had to be consulted. Since there are no full-scale published accounts of the hazard and its control, the research involved building a story almost exclusively from primary documents. Archives of public agencies provided relevant statistical information and legislative histories. Interviews and phone conversations were held with persons who had been involved with the problem at some time during their lives. Public directories and written accounts of other health hazards supplied useful material.

From this investigation, it appeared that at least four historical factors affected the ebb and flow of official concern about the radiation hazard. They are: (1) national needs for uranium ore; (2) the visibility of the hazard itself; (3) the stability and scale of the uranium mining industry; and (4) the vagaries in the formulation, at upper levels, of an official policy to meet the hazard.

Three types of organizations had a direct relationship to the hazard and to each other (interorganizational influence) in their daily business. Each had a unique way of responding. The companies which mined uranium responded differently from the unions which organized or attempted to organize miners, and government agencies which supervised the industry responded in yet a different way.

It is possible to depict a chain of events leading to the health situation confronting uranium miners today. This chain, in the nature of an extended hypothesis, runs as follows:

1. Several "historical" factors, including the national security crisis; the speculative and unstable nature of the early uranium industry; the absence of official policy to control radiation in mines; and the invisible nature of the radiation hazard;

2. Led to the neglect of miner health by the organizations most routinely concerned with industrial activities: mining companies, unions and government enforcement agencies;

3. Which led to the very slow amelioration of hazardous radiation conditions;

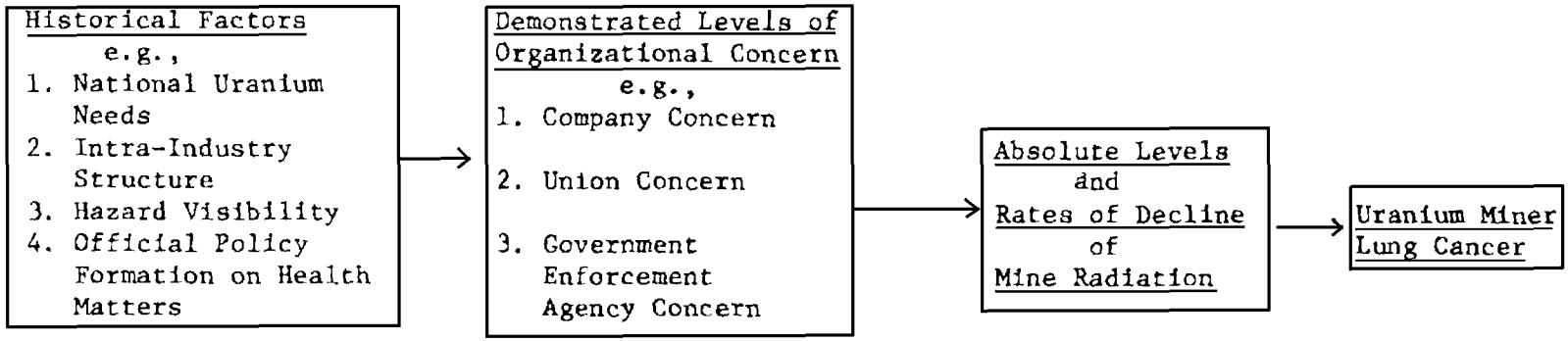
4. Which ultimately led to death and disease.

This hypothesis is portrayed graphically in Figure 1.

Given the hypothesis suggested by the historical survey, it was necessary to define variables which depicted its elements: the "historical" factors, the level of organizational "concern," and the health hazard itself. Once defined, the variables had to be measured. The process of defining and measuring the variables follows shortly.

Figure 1

Proposed Model of the Historical Process
By Which A Health Hazard
To Uranium Miners
Was Solved



Data Collection

Here it is pointed out that the underlying data which elucidated and sometimes gave quantitative standing to the variables came from many different sources. Public directories supplied most figures on mineral production, sales and exploration. Insurance records were studied for evidence of claims by miners of injury due to radiation. A content analysis of statutes, congressional records, legislative histories and the federal register helped to ascertain the level of attention devoted to the problem by federal and state level agencies over time. Annual policy statements issued by an industry lobby, the Colorado Mining Association, gave evidence of industry concern.

A thorough examination was made of the mining records of several public agencies.[78] These agencies included the Colorado Bureau of Mines, the Public Health Service and the Atomic Energy Commission, Western Operations Division. From a complete enumeration of the 923 uranium mines in Colorado operating between the years 1950 and 1969, a group of 540 mines was selected for study.[79] (See Table 1 for an illustration of the exclusion of mines from the project sample). These mine operated for a minimum of one year to a maximum of twenty years between 1950 and 1969. Information was collected for each mine for each year it operated. This resulted in the consideration of 3,623 cases or 3,623 mine-operation years. (See Table 2)

For each mine, for each year it operated, information was assembled as to: owner; operator; years of active operation; changes in ownership and operation continuity; number of underground miners employed during each year of operation; approximate level of productivity; union affiliation, if any; number of health and safety sanctions with respect to mine radiation. Among other things, this material permitted analysis of the scale and stability of the industry over time, the history of government enforcement activities, the degree of unionization the industry experiences, and the changing levels of radiation in mines.

In order to describe the process of controlling a worker health hazard from the standpoint of some of the individuals involved, a series of in-depth and open-ended interviews was conducted with representatives of the company, union and government agency sectors of the uranium mining industry. A total of 59 exploratory and in-depth interviews was held with respondents representing companies mining uranium, unions which organized uranium mill workers or miners, federal and state level inspectors for the Bureau of Mines and representatives of the Atomic Energy Commission, as well as medical researchers, health officials and insurance commissioners involved with the problem. (See Table 3) Respondents were encouraged to: describe their occupational and family background; answer specific questions related to the health hazard to miners; express opinions on the causes, magnitude and sources of reduction in radiation in mines and talk generally on the locus of responsibility for worker health and safety on the job.

Table 1

Reasons For Exclusion of Mines From The
Project Mine Sample

Complete Enumeration of Mines	923
Removal due to Identification Ambiguity	111
Removal due to Insufficient Information	37
Removal due to Absence of At Least One On-Site Mine Radiation Assessment	235
Total	383
Total Number Removed	383
Number in Project Mine Sample	540

Table 2

Numbers of Project Mines That Operated
Between 1950 and 1969
By Year

1950... 30	1960...263
1951... 58	1961...269
1952...104	1962...249
1953...128	1963...217
1954...146	1964...174
1955...165	1965...182
1956...212	1966...218
1957...246	1967...182
1958...234	1968...161
1959...258	1969...127

Table 3

Organizational Affiliation of Project Respondents

Organization	Preliminary Phase (Oct. 1972-Dec, 1972) Telephone Interview	Preliminary Phase (Oct. 1972-Dec, 1972) Personal Interview	Phase II (April 1973-July 1973) Telephone Interview	Phase II (April 1973-July 1973) Personal Interview
Government Enforcement Agency				
State Level	0	3	0	4
Federal Level	3	3	0	4
Labor Organization	9	2	0	4
Mining Company	0	0	0	6
Health Agency	6	8	0	0
Insurance Agency	2	5	0	0
Totals	20	21	0	18

The Project Variables

A word of caution about the eight variables operationalized for study is in order. While the variables hopefully measure what they purport to measure, they are not always testable with the precision common to experimental studies or survey research. This stems from infirmities of data collected from archival material, published directories and unstructured, "elite" interviews.[80]

A few examples illustrate. The chaotic state of the early uranium mining industry, characterized by wildcat prospecting and the rapid appearance and disappearance of mines, was reflected in the turbulence of the records. Miners with limited literacy skills maintained the mining records consulted for analysis. Partly as a result of this, the records were frequently incomplete, inaccurate, unstandardized and insensitive to subtle changes in radiation levels. Too, the variability of mine radiation itself presented a problem; radiation levels change day to day, hour to hour. Finally, since the study necessitated combining information on a single mine from a number of different sources, differences in the time of year during which various agencies collected information in mines had the potential to lead to misleading results.

Despite these problems, however, the utilization of the continuous records of public agencies was the only way of acquiring large amounts of longitudinal information. With all its shortcomings, information from archives may also have an element of non-reactivity that is not a feature of the interview or questionnaire.

In interviewing, no attempt was made to randomly sample respondents. Rather, individuals who proved themselves well informed and well connected with the problem were questioned in depth. They often suggested additional informants and tactics, secured additional information and offered comprehensive interpretations of the topic. Their influence on the project exceeded their numerical strength. The procedure, however, was the most appropriate for studying a relatively obscure and frequently technical subject. Although they were not suitable for statistical analysis, the interview results included useful suggestions on new sources of data and interview discussion topics. The unstructured, in-depth format also contributed to the favorable response to the interview.

THE DEPENDENT VARIABLE: WORKER HEALTH

The main dependent variable of the project is miner health. It is the actual incidence of death and disease among miners engaged in uranium mining. In this study, however, miner health is measured indirectly. It is assessed in terms of the environmental quality of the

mine, i.e., the level of radiation and/or the rate of radiation decline. That this is a reliable indicator is proven in the accumulated evidence associating mine radiation with respiratory ailments.[81] Public Health Service studies of miner health have demonstrated that the uranium mining population is subject to significantly elevated risks of lung cancer, a risk often sixteen times the rate experienced by the non-mining population. Moreover, the incidence of malignancies among miners increases with prolonged and more intense exposure to mine radiation.

Since prolonged exposure to high concentrations of radiation leads to lung cancer, it is assumed that low levels of radiation and a rapid rate of decline of mine radiation will enhance the health of miners. Radiation levels are measured in terms of radon concentrations and the rate of decline thereof.

A slightly revised version of the hypothesis on worker health combining the incidence of disease with the level of radiation in mines is portrayed in Figure 2.

THE INTERMEDIATE INDEPENDENT VARIABLE: ORGANIZATIONAL CONCERN

Moving one step backwards in the hypothesized chain of events we come to "organizational concern." "Organizational concern" is measured not by the attitudes of those in the organizations in positions to become aware of the problem, but, rather, by actual actions taken by the organizations to meet the problem. Three variables handle the concern demonstrated by each organization of interest.

Company Concern was measured in terms of voluntary company activities represented by:

1. The average, yearly expenditures, per ton of uranium ore mined, for ventilation equipment made by the industry.

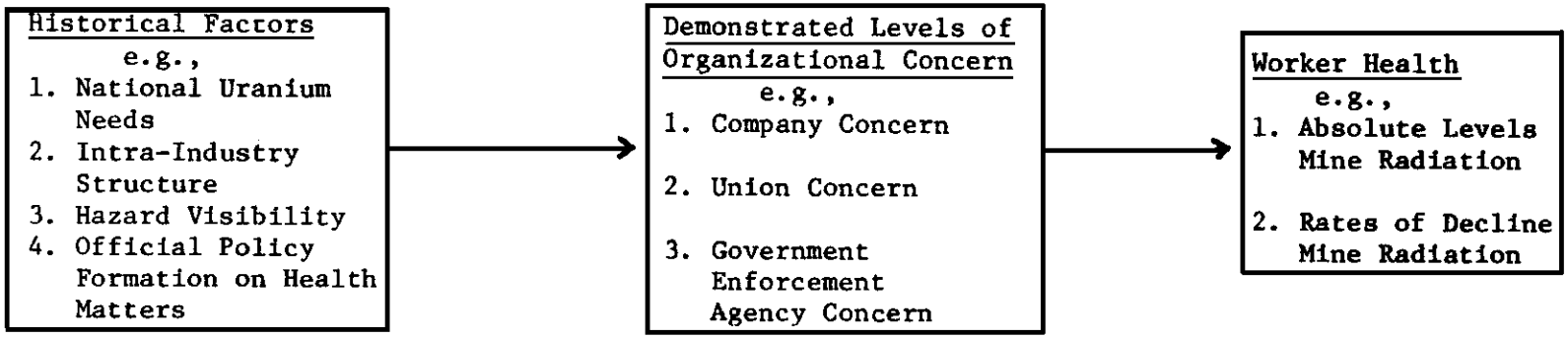
2. The average, yearly number of people employed by the industry for health and safety matters.

3. The number of times the problem of miner health is mentioned in the yearly policy statements of a mining industry association, The Colorado Mining Association.

Expenditures for ventilation and personnel directly measure efforts to reduce radiation. Mention in policy statements assesses the concern of decision-makers about the problem. It is assumed that the arousal of such concern is a pre-requisite for problem-solving activity.

Figure 2

Revised Model of the Historical Process
By Which A Health Hazard
To Uranium Miners
Was Solved



Government Agency Concern was measured in terms of the intensity of regulating activity, specifically:

1. The annual, average number of inspections conducted at each mine by government enforcement agents.

2. The annual, average number of sanctions of each variety, issued to mine operators by enforcement agents, for radiation violations.

Inspections and sanctions were the means available to government regulators to maintain health and safety standards in mines. Three types of sanctions were administered by the government to mine owners who violated health codes on radiation. General Orders invoked no penalty and were used to correct mild ventilation problems or first-time offenders. Remove Men Orders called for the withdrawal of miners (except for the purposes of installing ventilation equipment from mine sections found to be in extreme violation of radiation codes). A Cease Operation Order was a less frequently applied variant of the remove men order. It required a halt of mineral production at excessively radioactive mines until environmental conditions were improved.

Union Concern was measured in one way.

1. The number of uranium mines per year that were represented by a labor organization.

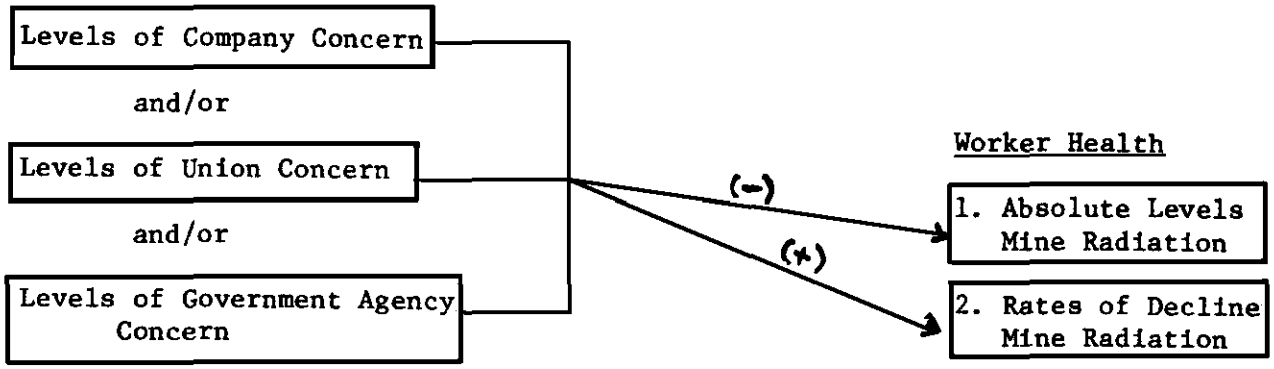
In the case of each measure, higher values are indicative of higher organizational concern; lower or nonexistent values represent a lower organizational concern. The higher the mean values of company, union and government agency concern, therefore, the more we would expect improvements in the radiation conditions in mines, and, in turn, the health of miners. The proposed relationships between organizational concern and worker health are portrayed in Figure 3.

THE PRIOR INDEPENDENT VARIABLES: HISTORICAL FACTORS

The so-called "historical" factors appear to explain why organizations displayed varying levels of concern at different points of time. Stated as a variable, National Uranium Needs means the demand for uranium over time. Hazard Visibility means the conspicuousness of the radiation hazard in uranium mines. Industry Scale and Stability means the structure and composition of the uranium industry over time. Official Concern means the role of upper level government agencies in formulating policies concerning the health hazard to miners (to be carried out by lower level agencies. See Government Agency Concern supra).

Figure 3

Proposed Relationships Between Organizational Concern Variables
And Worker Health



Key
(-) Inverse Relationship
(+) Direct Relationship

Variable measures were culled from official directories and the files of public agencies involved with uranium mining. National Uranium Needs, for example, were measured by the following items.

1. The annual tonnage of uranium concentrate purchased by the Atomic Energy Commission, 1947-1970.

2. The average annual price, per pound of uranium concentrate paid by the Atomic Energy Commission, 1947-1970.

3. The percentage of government owned mines, per year, 1947-1970.

4. The annual number of operating uranium mines, 1947-1970.

Tonnage measures demand for uranium in an indirect manner. The assumption here is that strong demands stimulated the industry to produce heavily and search for new uranium deposits. Government owned mines, production on government leases and the purchases of the ore by the government at guaranteed prices all measure preferential treatment of the industry by the government. It is assumed that such treatment reflected an underlying need for uranium supplies. The price paid for uranium over time is a direct measure of uranium needs. Price varied with levels of supply and demand.

The measure of Hazard Visibility included:

1. The annual number of deaths attributed (by the Public Health Service) to lung cancer contracted in uranium mining.

2. The average, annual expenditures made to compensate victims of lung cancer caused by mine radiation.

3. The annual number of compensation cases filed and awarded to miners claiming to have contracted lung cancer in uranium mining.

4. The annual number of articles on the subject of lung cancer among uranium miners that appeared in the newspaper, the Denver Post.

Deaths, compensation claims, dollars expended to afflicted miners and their families and articles on the subject appearing in the popular press measured the conspicuousness of the hazard to public agencies and the general public. It is assumed that awareness of the effects of exposure to radiation implied recognition of the hazard itself.

Measures of Industry Scale and Stability included:

1. The annual percentage of mines in the project sample owned by large mining companies.

2. The annual percentage of mines in the project sample producing 500 tons or more on a monthly basis.

3. The annual percentage of mines in the project employing sixteen men or more.

Mines owned by individuals or partnerships as opposed to large companies is a measure of industry scale and stability. "Infintesimal businesses"[82] are small-scale units with a short life expectancy. They are transient and economically marginal. It is assumed that to the extent that the uranium mining industry was composed of such forms of business organizations, it was unstable and small-scale. Modern giant corporations concentrate large supplies of capital and are relatively permanent. To the extent that the uranium mining industry was composed of this latter form of business organization, it was stable and large-scale.

Evidence of official concern was largely drawn from legislative records and state-level statutes bearing on radiation in mines. The demonstration of Official Concern by federal and state level agencies toward the hazard was represented by high values on the following items:

1. The number of bills relating to uranium health hazards, including agency appropriations, introduced in either house of Congress, per year.

2. The number of lines of regulations in the Federal Register related to uranium mine safety, per year.

3. The dollar appropriations to enforcement agencies in any uranium safety connection, per year.

VARIABLE RELATIONSHIPS

The hypothesis postulates that intense National Uranium Needs adversely affected the level of concern demonstrated by companies, unions and government agencies. Intense demands for the ore and official preoccupation with guaranteeing an adequate supply of uranium served to distract attention from the imperiled health of miners. Conversely, diminished demands for the ore are postulated to have enhanced worker health. Once the urgency for uranium production had subsided, companies, unions and government agencies devoted more attention to the problems of the worker.

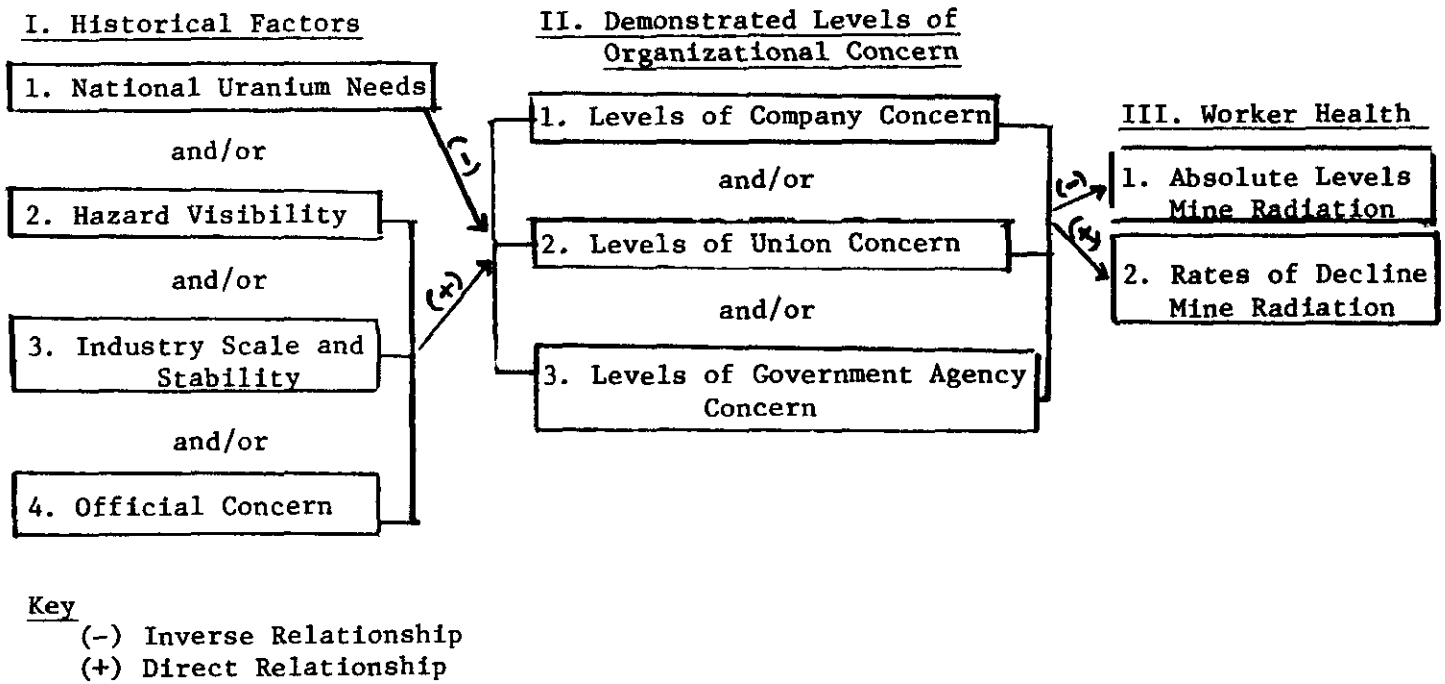
Measures indicative of high levels of Hazard Visibility, Industry Scale and Stability and Official Concern, on the other hand, are all hypothesized to have stimulated the demonstration of concern by companies, unions and government agencies. For example, in the face of conspicuous

evidence of injury to workers, organizational concern was aroused and efforts were made to control the problem. This had salubrious consequences for the worker. Official debate, study and the promulgation of nation-wide policies concerning mine radiation were also helpful in promoting an atmosphere attentive to health considerations. With the emergence of an official mandate, companies, unions and enforcement agencies were better able to achieve widespread compliance with radiation goals. The greater stability of the mining industry also enhanced the health picture of the miners. A large-scale and mature industry was easier to monitor by government agencies than a highly speculative and transient one. This type of industry also demonstrated greater responsibility for the welfare of its workers.

Figure 4 summarizes the proposed relationships to date. One can easily conceive of interactive effects between and among "concern" variables and variables portraying "historical" factors. For example, demonstrations of government concern might have sparked company actions to control mine radiation. Increased visibility of the uranium hazard might have fueled efforts to promulgate official policies concerning radiation in mines. There is also a possibility of feedback effects between the radiation situation and the concern displayed by organizations. Thus, sluggish rates of radiation decline may have triggered more intense government concern and rapid progress in decline, the opposite response. For the sake of simplicity, however, the model is assumed to be recursive; interactive and feedback effects will be ignored for the present.

Figure 4

Proposed Model of Variable Relationships



Key
(-) Inverse Relationship
(+) Direct Relationship