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# The Population Ecology of Organizations<sup>1</sup>

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A population ecology perspective on organization-environment relations is proposed as an alternative to the dominant adaptation perspective. The strength of inertial pressures on organizational structure suggests the application of models that depend on competition and selection in populations of organizations. Several such models as well as issues that arise in attempts to apply them to the organization-environment problem are discussed.

## I. INTRODUCTION

Analysis of the effects of environment on organizational structure has moved to a central place in organizations theory and research in recent years. This shift has opened a number of exciting possibilities. As yet nothing like the full promise of the shift has been realized. We believe that the lack of development is due in part to a failure to bring ecological models to bear on questions that are preeminently ecological. We argue for a reformulation of the problem in population ecology terms.

Although there is a wide variety of ecological perspectives, they all focus on selection. That is, they attribute patterns in nature to the action of selection processes. The bulk of the literature on organizations subscribes to a different view, which we call the adaptation perspective.<sup>2</sup> According

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<sup>2</sup> There is a subtle relationship between selection and adaptation. Adaptive learning for individuals usually consists of selection among behavioral responses. Adaptation for a population involves selection among types of members. More generally, processes involving selection can usually be recast at a higher level of analysis as adaptation processes. However, once the unit of analysis is chosen there is no ambiguity in distinguishing selection from adaptation. Organizations often adapt to environmental conditions in concert and this suggests a systems effect. Though few theorists would deny the existence of such systems effects, most do not make them a subject of central concern. It is important to notice that, from the point of view embraced by sociologists whose interests focus on the broader social system, selection in favor of organizations with one set of properties to the disfavor of those with others is often an adaptive process. Societies and communities which consist in part of formal organizations adapt partly through processes that adjust the mixture of

to the adaptation perspective, subunits of the organization, usually managers or dominant coalitions, scan the relevant environment for opportunities and threats, formulate strategic responses, and adjust organizational structure appropriately.

The adaptation perspective is seen most clearly in the literature on management. Contributors to it usually assume a hierarchy of authority and control that locates decisions concerning the organization as a whole at the top. It follows, then, that organizations are affected by their environments according to the ways in which managers or leaders formulate strategies, make decisions, and implement them. Particularly successful managers are able either to buffer their organizations from environmental disturbances or to arrange smooth adjustments that require minimal disruption of organizational structure.

A similar perspective, often worded differently, dominates the sociological literature on the subject. It plays a central role in Parsons's (1956) functional analysis of organization-environment relations and it is found in the more strictly Weberian tradition (see Selznick 1957). It is interesting to note that, while functionalists have been interested in system effects and have based much of the logic of their approach on survival imperatives, they have not dealt with selection phenomena. This is probably a reaction against organization theory which reflects social Darwinism.

Exchange theorists have also embraced the adaptation perspective (Levine and White 1961). And it is natural that theories emphasizing decision making take the adaptation view (March and Simon 1958; Cyert and March 1963). Even Thompson's (1967) celebrated marriage of open-systems and closed-systems thinking embraced the adaptation perspective explicitly (see particularly the second half of Thompson's book).

Clearly, leaders of organizations do formulate strategies and organizations do adapt to environmental contingencies. As a result at least some of the relationship between structure and environment must reflect adaptive behavior or learning. But there is no reason to presume that the great structural variability among organizations reflects only or even primarily adaptation.

There are a number of obvious limitations on the ability of organizations to adapt. That is, there are a number of processes that generate structural inertia. The stronger the pressures, the lower the organizations'

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various kinds of organizations found within them. Whereas a complete theory of organization and environment would have to consider both adaptation and selection, recognizing that they are complementary processes, our purpose here is to show what can be learned from studying selection alone (see Aldrich and Pfeffer [1976] for a synthetic review of the literature focusing on these different perspectives).

adaptive flexibility and the more likely that the logic of environmental selection is appropriate. As a consequence, the issue of structural inertia is central to the choice between adaptation and selection models.

The possibility that organization structure contains a large inertial component was suggested by Burns and Stalker (1961) and Stinchcombe (1965). But, on the whole the subject has been ignored. A number of relevant propositions can be found in the organizations literature, however.

Inertial pressures arise from both internal structural arrangements and environmental constraints. A minimal list of the constraints arising from internal considerations follows.

1. An organization's investment in plant, equipment, and specialized personnel constitutes assets that are not easily transferable to other tasks or functions. The ways in which such sunk costs constrain adaptation options are so obvious that they need not be discussed further.

2. Organizational decision makers also face constraints on the information they receive. Much of what we know about the flow of information through organizational structures tells us that leaders do not obtain anything close to full information on activities within the organization and environmental contingencies facing the subunits.

3. Internal political constraints are even more important. When organizations alter structure, political equilibria are disturbed. As long as the pool of resources is fixed, structural change almost always involves redistribution of resources across subunits. Such redistribution upsets the prevailing system of exchange among subunits (or subunit leaders). So at least some subunits are likely to resist any proposed reorganization. Moreover, the benefits of structural reorganization are likely to be both generalized (designed to benefit the organization as a whole) and long-run. Any negative political response will tend to generate short-run costs that are high enough that organizational leaders will forego the planned reorganization. (For a more extensive discussion of the ways in which the internal political economy of organizations impedes change or adaptation, see Downs [1967] and Zald [1970].)

4. Finally, organizations face constraints generated by their own history. Once standards of procedure and the allocation of tasks and authority have become the subject of normative agreement, the costs of change are greatly increased. Normative agreements constrain adaptation in at least two ways. First, they provide a justification and an organizing principle for those elements that wish to resist reorganization (i.e., they can resist in terms of a shared principle). Second, normative agreements preclude the serious consideration of many alternative responses. For example, few research-oriented universities seriously consider adapting to

declining enrollments by eliminating the teaching function. To entertain this option would be to challenge central organizational norms.<sup>3</sup>

The external pressures toward inertia seem to be at least as strong. They include at least the following factors.

1. Legal and fiscal barriers to entry and exit from markets (broadly defined) are numerous. Discussions of organizational behavior typically emphasize barriers to entry (state licensed monopoly positions, etc.). Barriers to exit are equally interesting. There are an increasing number of instances in which political decisions prevent firms from abandoning certain activities. All such constraints on entry and exit limit the breadth of adaptation possibilities.

2. Internal constraints upon the availability of information are paralleled by external constraints. The acquisition of information about relevant environments is costly particularly in turbulent situations where the information is most essential. In addition, the type of specialists employed by the organization constrains both the nature of the information it is likely to obtain (see Granovetter 1973) and the kind of specialized information it can process and utilize.

3. Legitimacy constraints also emanate from the environment. Any legitimacy an organization has been able to generate constitutes an asset in manipulating the environment. To the extent that adaptation (e.g., eliminating undergraduate instruction in public universities) violates the legitimacy claims, it incurs considerable costs. So external legitimacy considerations also tend to limit adaptation.

4. Finally, there is the collective rationality problem. One of the most difficult issues in contemporary economics concerns general equilibria. If one can find an optimal strategy for some individual buyer or seller in a competitive market, it does not necessarily follow that there is a general equilibrium once all players start trading. More generally, it is difficult to establish that a strategy that is rational for a single decision maker will be rational if adopted by a large number of decision makers. A number of solutions to this problem have been proposed in competitive market theory, but we know of no treatment of the problem for organizations generally. Until such a treatment is established we should not presume that a course of action that is adaptive for a single organization facing some changing environment will be adaptive for many competing organizations adopting a similar strategy.

A number of these inertial pressures can be accommodated within the adaptation framework. That is, one can modify and limit the perspective in order to consider choices within the constrained set of alternatives. But

<sup>3</sup> Meyer's (1970) discussion of an organization's charter adds further support to the argument that normative agreements arrived at early in an organization's history constrain greatly the organization's range of adaptation to environmental constraints.

to do so greatly limits the scope of one's investigation. We argue that in order to deal with the various inertial pressures the adaptation perspective must be supplemented with a selection orientation.

We consider first two broad issues that are preliminary to ecological modeling. The first concerns appropriate units of analysis. Typical analyses of the relation of organizations to environments take the point of view of a single organization facing an environment. We argue for an explicit focus on populations of organizations. The second broad issue concerns the applicability of population ecology models to the study of human social organization. Our substantive proposal begins with Hawley's (1950, 1968) classic statement on human ecology. We seek to extend Hawley's work in two ways: by using explicit competition models to specify the process producing isomorphism between organizational structure and environmental demands, and by using niche theory to extend the problem to dynamic environments. We argue that Hawley's perspective, modified and extended in these ways, serves as a useful starting point for population ecology theories of organizations.

## II. POPULATION THINKING IN THE STUDY OF ORGANIZATION-ENVIRONMENT RELATIONS

Little attention is paid in the organizations literature to issues concerning proper units of analysis (Freeman 1975). In fact, choice of unit is treated so casually as to suggest that it is not an issue. We suspect that the opposite is true—that the choice of unit involves subtle issues and has far-reaching consequences for research activity. For instance, in the case at hand, it determines which of several ecological literatures can be brought to bear on the study of organization-environment relations.

The comparison of unit choice facing the organizational analyst with that facing the bioecologist is instructive. To oversimplify somewhat, ecological analysis is conducted at three levels: individual, population, and community. Events at one level almost always have consequences at other levels. Despite this interdependence, population events cannot be reduced to individual events (since individuals do not reflect the full genetic variability of the population) and community events cannot be simply reduced to population events. Both the latter employ a population perspective which is not appropriate at the individual level.

The situation faced by the organizations analyst is more complex. Instead of three levels of analysis, he faces at least five: (1) members, (2) subunits, (3) individual organizations, (4) populations of organizations, and (5) communities of (populations of) organizations. Levels 3–5 can be seen as corresponding to the three levels discussed for general ecology, with the individual organization taking the place of the individual organ-

ism. The added complexity arises because organizations are more nearly decomposable into constituent parts than are organisms. Individual members and subunits may move from organization to organization in a manner which has no parallel in nonhuman organization.

Instances of theory and research dealing with the effects of environments on organizations are found at all five levels. For example, Crozier's well-known analysis of the effects of culture on bureaucracy focuses on the cultural materials members bring to organizations (1964). At the other end of the continuum we find analyses of "organizational fields" (Turk 1970; Aldrich and Reiss 1976). But, the most common focus is on *the* organization and *its* environment. In fact, this choice is so widespread that there appears to be a tacit understanding that individual organizations are the appropriate units for the study of organization-environment relations.

We argue for a parallel development of theory and research at the population (and, ultimately, the community) level. Because of the differing opinions about levels of analysis, "population" has at least two referents. Conventional treatments of human ecology suggest that the populations relevant to the study of organization-environment relations are those aggregates of members attached to the organization or, perhaps, served by the organization. In this sense, the organization is viewed as analogue to a community: it has collective means of adapting to environmental situations. The unit character of a population so defined depends on shared fate. All members share to some extent in the consequences of organizational success or failure.

We use the term population in a second sense: to refer to aggregates of organizations rather than members. Populations of organizations must be alike in some respect, that is, they must have some unit character. Unfortunately, identifying a population of organizations is no simple matter. The ecological approach suggests that one focus on common fate with respect to environmental variations. Since all organizations are distinctive, no two are affected identically by any given exogenous shock. Nevertheless, we can identify classes of organizations which are relatively homogeneous in terms of environmental vulnerability. Notice that the populations of interest may change somewhat from investigation to investigation depending on the analyst's concern. Populations of organizations referred to are not immutable objects in nature but are abstractions useful for theoretical purposes.

If we are to follow the lead of population biologists, we must identify an analogue to the biologist's notion of species. Various species are defined ultimately in terms of genetic structure. As Monod (1971) indicates, it is useful to think of the genetic content of any species as a blueprint. The blueprint contains the rules for transforming energy into structure.

Consequently all of the adaptive capacity of a species is summarized in the blueprint. If we are to identify a species analogue for organizations, we must search for such blueprints. These will consist of rules or procedures for obtaining and acting upon inputs in order to produce an organizational product or response.

The type of blueprint one identifies depends on substantive concerns. For example, Marschak and Radner (1972) employ the term "organizational form"<sup>4</sup> to characterize the key elements of the blueprint as seen within a decision-making framework. For them the blueprint or form has two functions: an information function that describes the rules used in obtaining, processing, and transmitting information about the states of external environments, and an activity function that states the rules used in acting on received information so as to produce an organizational response. To the extent that one can identify classes of organizations that differ with regard to these two functions, one can establish classes or forms of organization.

Since our concerns extend beyond decision making, however, we find Marschak and Radner's definition of forms too limiting. In fact, there is no reason to limit a priori the variety of rules or functions that may define relevant blueprints. So for us, an organizational form is a blueprint for organizational action, for transforming inputs into outputs. The blueprint can usually be inferred, albeit in somewhat different ways, by examining any of the following: (1) the formal structure of the organization in the narrow sense—tables of organization, written rules of operation, etc.; (2) the patterns of activity within the organization—what actually gets done by whom; or (3) the normative order—the ways of organizing that are defined as right and proper by both members and relevant sectors of the environment.

To complete the species analogue, we must search for qualitative differences among forms. It seems most likely that we will find such differences in the first and third areas listed above, formal structure and normative order. The latter offers particularly intriguing possibilities. Whenever the history of an organization, its politics, and its social structure are encoded in a normative claim (e.g., professionalization and collegial authority), one can use these claims to identify forms and define populations for research.

Having defined the organizational form, we can provide a more precise definition of a population of organizations. Just as the organizational analyst must choose a unit of analysis, so must he choose a system for study. Systems relevant to the study of organization-environment relations are

<sup>4</sup>The term "organizational form" is used widely in the sociological literature (see Stinchcombe 1965).

usually defined by geography, by political boundaries, by market or product considerations, etc. Given a systems definition, a population of organizations consists of all the organizations within a particular boundary that have a common form. That is, the population is the form as it exists or is realized within a specified system.

Both uses of the term population (and the ecological theories implied thereby) are likely to prove beneficial to the study of organizational structure. The first, more common, view suggests that organizational structure ought to be viewed as an outcome of a collective adaptive process. According to this view, structure and change ought to depend on the adaptiveness of subunits and on the differential access of subunits to environmental resources. The second view ignores the adaptive activities of elements within the organization except as they constitute organizational structure. It focuses on the organization as an adapting unit. Certainly both perspectives are needed. We are concerned here only with the latter, however.

Finally, we would like to identify the properties of populations most interesting to population ecologists. The main concern in this regard was expressed clearly by Elton (1927): "In solving ecological problems we are concerned with *what animals do* in their capacity as whole, living animals, not as dead animals or as a series of parts of animals. We have next to study the circumstances under which they do those things, and, most important of all, the limiting factors which prevent them from doing certain other things. By solving these questions it is possible to discover the reasons for *the distribution and numbers of animals in nature.*" Hutchinson (1959) in the subtitle to his famous essay, "Homage to Santa Rosalia," expressed the main focus even more succinctly: "Why Are There So Many Kinds of Animals?" Taking our lead from these distinguished ecologists, we suggest that a population ecology of organizations must seek to understand the distributions of organizations across environmental conditions and the limitations on organizational structures in different environments, and more generally seek to answer the question, Why are there so many kinds of organizations?

### III. DISCONTINUITIES IN ECOLOGICAL ANALYSIS

Utilization of models from ecology in the study of organizations poses a number of analytic challenges involving differences between human and nonhuman organizations with regard to their essential ingredients. Consider, first, the nongenetic transmission of information. Biological analyses are greatly simplified by the fact that most useful information concerning adaptation to the environment (which information we call structure) is transmitted genetically. Genetic processes are so nearly invariant that

extreme continuity in structure is the rule. The small number of imperfections generates structural changes, which, if accepted by the environment, will be transmitted with near invariance. The extreme structural invariance of species greatly simplifies the problem of delimiting and identifying populations. More important, the adaptiveness of structure can be unambiguously identified with net reproduction rates. When a population with given properties increases its net reproduction rate following an environmental change, it follows that it is being selected for. This is why modern biologists have narrowed the definition of fitness to the net reproductive rate of population.

Human social organization presumably reflects a greater degree of learning or adaptation. As a result it is more difficult to define fitness in a precise way. Under at least some conditions, organizations may undergo such extreme structural change that they shift from one form to another. As a result, extreme adaptation may give rise to observed changes that mimic selection. This is particularly problematic when the various organizational forms are similar on many dimensions.

We have argued previously (Hannan and Freeman 1974) for a composite measure of fitness that includes both selection (actual loss of organizations) and mobility among forms (extreme adaptation). Fitness would then be defined as the probability that a given form of organization would persist in a certain environment. We continue to believe that such an approach has value, but we now believe that it is premature to combine adaptation and selection processes. The first order of business is to study selection processes for those situations in which inertial pressures are sufficiently strong that mobility among forms is unlikely.

Furthermore, it is worth noting that the capacity to adapt is itself subject to evolution (i.e., to systematic selection). As we argue below, organizations develop the capacity to adapt at the cost of lowered performance levels in stable environments. Whether or not such adaptable organizational forms will survive (i.e., resist selection) depends on the nature of the environment and the competitive situation. Therefore, a selection point of view treats high levels of adaptability as particular evolutionary outcomes.

There is a second sense in which human ecology appears to differ from bioecology. Blau and Scott (1962) point out that, unlike the usual biological situation, individual organizations (and populations of organizations) have the potential to expand almost without limit. The expandability of primitive elements is a problem because of our focus on the distribution of organizational forms over environments. A given form (e.g., formal bureaucracy) can expand throughout some system, market, or activity, either because one bureaucracy grows or because many bureaucracies are founded. Either process will generate an increase in the prev-

alence of bureaucratic organizational activity. A literal application of population ecology theory to the problem of organizational change would involve simply counting relative numbers in populations. Such a procedure may miss a phenomenon of central interest to the organizational analyst. Winter (1964), in discussing the analytic problem raised here, suggests distinguishing between survival, which describes the fate of individual organizations, and viability, which describes the "share of market" of a given organizational form.

We find at least as much merit in another perspective on the issue of size. Many theorists have asserted that structural change attends growth; in other words, a single organization cannot grow indefinitely and still maintain its original form. For instance, a mouse could not possibly maintain the same proportion of body weight to skeletal structure while growing as big as a house. It would neither look like a mouse nor operate physiologically like a mouse. Boulding (1953) and Haire (1959) argue that the same is true for organizations. Caplow (1957), building on work by Graicunas (1933) and others, argues that the ability of each member of an organization to carry on face-to-face interactions with each of the others declines with the number of organizational participants. This creates a shift in the nature of interactions such that they assume a more impersonal, formal style. Blau and a number of coauthors have argued for similar causal effects of size on structure (Blau and Scott 1962, pp. 223-42; Blau and Schoenherr 1971; Blau 1972). If it is true that organizational form changes with size, selection mechanisms may indeed operate with regard to the size distribution. When big organizations prevail it may be useful to view this as a special case of selection, in which the movement from "small form" to "large form" is theoretically indistinguishable from the dissolution ("death") of small organizations and their replacement by (the "birth" of) large organizations.

In sum, we have identified a number of challenges. The first concerns the two sources of change, selection and adaptive learning. We feel that the organizations literature has overemphasized the latter at the expense of the former. Much more is known about decision-making practices, forecasting, and the like than about selection in populations of organizations. The second challenge involves the distinction between selection and viability. Whether such a distinction is necessary depends on the results of research on size which is currently being pursued by many organization researchers.

#### IV. THE PRINCIPLE OF ISOMORPHISM

In the best developed statement of the principles of human ecology, Hawley (1968) answers the question of why there are so many kinds of

organizations. According to Hawley, the diversity of organizational forms is isomorphic to the diversity of environments. In each distinguishable environmental configuration one finds, in equilibrium, only that organizational form optimally adapted to the demands of the environment. Each unit experiences constraints which force it to resemble other units with the same set of constraints. Hawley's explanation places heavy emphasis on communication patterns and structural complements of those patterns: "[organization units] must submit to standard terms of communication and to standard procedures in consequence of which they develop similar internal arrangements within limits imposed by their respective sizes" (1968, p. 334).

While the proposition seems completely sound from an ecological perspective, it does not address a number of interesting considerations. There are at least two respects in which the isomorphism formulation must be modified and extended if it is to provide satisfactory answers to the question posed. The first modification concerns the mechanism or mechanisms responsible for equilibrium. In this respect, the principle of isomorphism must be supplemented by a criterion of selection and a competition theory. The second modification deals with the fact that the principle of isomorphism neither speaks to issues of optimum adaptation to changing environments nor recognizes that populations of organizations often face multiple environments which impose somewhat inconsistent demands. An understanding of the constraints on organizational forms seems to require modeling of multiple, dynamic environments. Of course, we cannot fully extend Hawley's principle here. We attempt only to outline the main issues and suggest particular extensions.

## V. COMPETITION THEORY

The first of the needed extensions is a specification of the optimization process responsible for isomorphism. We have already discussed two mechanisms: selection and adaptive learning. Isomorphism can result either because nonoptimal forms are selected out of a community of organizations or because organizational decision makers learn optimal responses and adjust organizational behavior accordingly. We continue to focus on the first of these processes: selection.

Consideration of optimization raises two issues: Who is optimizing, and what is being optimized? It is quite commonly held, as in the theory of the firm, that organizational decision makers optimize profit over sets of organizational actions. From a population ecology perspective, it is the environment which optimizes.<sup>5</sup> Whether or not individual organiza-

<sup>5</sup> In biological applications, one assumes that power (in the physical sense) is optimized by natural selection in accordance with the so-called Darwin-Lotka law.

tions are consciously adapting, the environment selects out optimal combinations of organizations. So if there is a rationality involved, it is the "rationality" of natural selection. Organizational rationality and environmental rationality may coincide in the instance of firms in competitive markets. In this case, the optimal behavior of each firm is to maximize profit and the rule used by the environment (market, in this case) is to select out profit maximizers. Friedman (1953) makes use of this observation to propose a justification of the theory of the firm in terms of the principles of evolution. However, Winter (1964) has argued convincingly that the actual situation is much more complicated than this and that it is most unusual for individual rationality and environmental or market rationality to lead to the same optima. When the two rationalities do not agree, we are concerned with the optimizing behavior of the environment.

A focus on selection invites an emphasis on competition. Organizational forms presumably fail to flourish in certain environmental circumstances because other forms successfully compete with them for essential resources. As long as the resources which sustain organizations are finite and populations have unlimited capacity to expand, competition must ensue.

Hawley (1950, pp. 201-3) following Durkheim (1947) among others, places a heavy emphasis on competition as a determinant of patterns of social organization. The distinctive feature of his model is the emphasis on the indirect nature of the process: "The action of all on the common supply gives rise to a reciprocal relation between each unit and all the others, if only from the fact that what one gets reduces by that amount what the others can obtain . . . without this element of indirection, that is, unless units affect one another through affecting a common limited supply, competition does not exist" (Hawley 1950, p. 202). In Hawley's model, competition processes typically involve four stages: (1) demand for resources exceeds supply; (2) competitors become more similar as standard conditions of competition bring forth a uniform response; (3) selection eliminates the weakest competitors; and (4) deposed competitors differentiate either territorially or functionally, yielding a more complex division of labor.

It is surprising that there is almost no reliance on competitive mechanisms in Hawley's later work. In particular, as we noted above, the rationale given for the isomorphism principle uses an adaptation logic. We propose to balance that treatment by adding an explicit focus on competition as a mechanism producing isomorphism.<sup>6</sup> In so doing, we can bring a rich set of formal models to bear on the problem.

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For the case of human social organization, one might argue that selection optimizes the utilization of a specific set of resources including but not restricted to the power and the time of members.

<sup>6</sup> We include only the first and third of Hawley's stages in our model of competi-

The first step in constructing an ecological model of competition is to state the nature of the population growth process. At a minimum we wish the model to incorporate the idea that resources available at any moment for each form of organization are finite and fixed. This corresponds with Hawley's notion of limited supply and Stinchcombe's (1965) argument that human communities have limited "capacities for organizing." We also wish to incorporate the view that the rate at which units are added to populations of organizations depends on how much of the fixed capacity has already been exhausted. The greater the unexhausted capacity in an environment, the faster should be the rate of growth of populations of organizations. But the rate at which populations of organizations can expand into unused capacity varies among forms of organization. So there are two distinctive ecological considerations: the capacity of the environment to support forms of organization and the rate at which the populations grow (or decline) when the environmental support changes.

In order to state the model formally, it is helpful to begin with the control function that Hummon, Doreian, and Teuter (1975) use to add dynamic considerations to Blau's theory of size and differentiation. The control model states that the rate of change in the size of any unit (here a population of organizations) varies proportionately with the difference between existing size,  $X$ , and the equilibrium level of size,  $X^*$ , permitted in that environment. Then one possible representation would be

$$\frac{dX}{dt} = f(X^* - X) = r(X^* - X). \quad (1)$$

In (1)  $X^*$  and  $r$  represent the limited supply or environmental capacity and the structural ability of the population of organizations to respond to changes in the environment, respectively.

A particular form of the general growth model in (1) underlies most population ecology work on competition. This is the logistic growth model (for per capita growth):

$$\frac{dX_1}{dt} = r_1 X_1 \left( \frac{k_1 - X_1}{k_1} \right) \quad (2)$$

where  $X_1$  denotes population size,  $k_1$  is the capacity of the environment to support  $X_1$  (this parameter is usually called the carrying capacity), and  $r_1$  is the so-called natural rate of increase of the population or the rate at which the population grows when it is far below the carrying capacity.

As we indicated above, both  $k$  and  $r$  are ecological parameters of foundation. We prefer to treat uniformity of response and community diversity as consequences of combinations of certain competitive processes and environmental features.

mental importance. Our research group has begun to compare various forms of organization by estimating the parameters of models like (2) for each form of organization. We have been successful to date in relating structural features of organizations such as complexity of core activity to variations in  $r$  and  $k$  (Nielsen and Hannan 1977; Freeman and Brittain 1977). This work, together with that of Hummon et al. (1975), gives us confidence that the model in (1) and/or (2) gives a good approximation of the growth of populations of organizations.

Up to this point we have presumed that the limits on growth reflect the finite nature of the environment (e.g., community wealth and mix of occupational skills). It is now time to reintroduce competition. According to Hawley, competition enters indirectly when the competitors lower the fixed supply. We can model this by following the lead of bioecologists and extending the logistic growth model. For example, consider a second population of organizations whose size is denoted by  $X_2$ . The two populations are said to compete if the addition of units of either decreases the rate of growth of the other. This will be the case when both populations are sustained by the same types of resources. Then the appropriate model is represented in the following system of growth equations (known as the Lotka-Volterra equations for competing populations):

$$\begin{aligned} \frac{dX_1}{dt} &= r_1 X_1 \left( \frac{k_1 - X_1 - \alpha_{12} X_2}{k_1} \right) \\ \frac{dX_2}{dt} &= r_2 X_2 \left( \frac{k_2 - X_2 - \alpha_{21} X_1}{k_2} \right) \end{aligned} \tag{3}$$

The coefficients  $\alpha_{12}$  and  $\alpha_{21}$ , called competition coefficients, denote the magnitude of the effect of increases in one population on the growth of the other. In this simple formulation, the only consequence of competition is to lower the carrying capacity of the environment for a population of organizations.

Analysis of (3) produces interesting qualitative results. It is not difficult to show that a stable two-population equilibrium exists for the system in (3) only if

$$\frac{1}{\alpha_{21}} < \frac{k_2}{k_1} < \alpha_{12}. \tag{4}$$

Therefore, very similar populations (i.e., populations with competition coefficients near unity) can coexist only under a very precise  $k_2/k_1$  ratio. As a result, when  $\alpha_{12} = \alpha_{21} = 1$ , no two-population equilibrium can be stable; any exogenous shock will result in the elimination of one of the populations. This result supports the generality of the widely cited "prin-

principle of competitive exclusion” (Gause 1934).<sup>7</sup> According to this principle, no two populations can continuously occupy the same niche. Populations are said to occupy the same niche to the extent that they depend on identical environmental resources. If they are identical, then the addition of an element to  $X_2$  has the same consequences for growth in  $X_1$  as does the addition of an element to  $X_1$ ; in other words, the competition coefficients are unity. The broad conclusion is that the greater the similarity of two resource-limited competitors, the less feasible is it that a single environment can support both of them in equilibrium.

If two populations of organizations sustained by identical environmental resources differ in some organizational characteristic, that population with the characteristic less fit to environmental contingencies will tend to be eliminated. The stable equilibrium will then contain only one population which can be said to be isomorphic to the environment.

In order to see the implications of the model for organizational diversity, we extend the Lotka-Volterra system to include  $M$  competitors:

$$\frac{dX_i}{dt} = r_i X_i (k_i - X_i - \sum \alpha_{ij} X_j) / k_i \quad (i = 1, \dots, M). \quad (5)$$

The general system (5) has a community equilibrium:

$$k_i = X_i + \sum \alpha_{ij} X_j \quad (i = 1, \dots, M). \quad (6)$$

These equations can be expressed in matrix form:

$$k = A x, \quad (7)$$

where  $x$  and  $k$  are  $(M \times 1)$  column vectors and  $A$  is the community matrix:

$$A = \begin{pmatrix} 1 & \alpha_{12} & \dots & \alpha_{1m} \\ \alpha_{21} & 1 & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \alpha_{m1} & \dots & \dots & 1 \end{pmatrix}$$

whose elements are the competition coefficients.

The so-called theory of community structure entails the analysis of the equilibrium behavior of the system of equation (7) from the perspective of postulated competition processes.<sup>8</sup> The results, though stated in

<sup>7</sup> This so-called principle has mostly suggestive value (see MacArthur [1972, pp. 43-46] for a penetrating critique of attempts to derive quantitative implications from Gause's principle; most of these criticisms do not apply to the qualitative inferences we consider).

<sup>8</sup> We restrict attention to the case in which all entries of  $A$  are nonnegative. Nega-

terms of species diversity, are quite general. In particular, one can show that when growth in population is constrained only by resource availability, the number of distinct resources sets an upper bound on diversity in the system.<sup>9</sup> Even more generally, the upper bound on diversity is equal to the number of distinct resources plus the number of additional constraints on growth (Levin 1970).

It is difficult to apply either result directly in order to calculate the upper bound on diversity even in the nonhuman context. The chief difficulty is that of identifying distinct constraints. A good deal of empirical work is required if one is to judge how different two constraints must be in order to have distinct consequences for community equilibria. The theorems do, however, imply useful qualitative results. If one can identify environmental changes which add constraints to a system or eliminate them, one can conclude that the upper bound of diversity is increased or decreased.

This broad qualitative result has a number of potential applications to the research problems of interest. For example, the expansion of markets and of state control mechanisms through social systems tends to have the consequence of eliminating or reducing the number of constraints which are idiosyncratic to local environments. Viewed from the perspective of the larger system, the process of expansion of the economic and political center should, then, tend to replace some local constraints with more uniform ones. As long as the local environments were heterogeneous at the outset, expansion of the center ought to reduce the number of constraints on organization in the whole system.

The theory just discussed implies on the one hand that the change in constraint structure ought to lower organizational diversity through the elimination of some population.<sup>10</sup> One can imagine, on the other hand, that in some local environments, the combination of unaltered local constraints and new larger system constraints might increase the total number of constraints in the local system. In that case, organizational diversity in those local environments should increase. Such an increase would result in the creation or adoption of new organizational forms.

The increasingly important role of the state in regulating economic and social action provides numerous opportunities for analyzing the impact of changes in constraint structures on the diversity of organizational

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tive entries are appropriate for predator/prey (or more generally, host/parasite) relations. The typical result for this case is cyclical population growth.

<sup>9</sup> A more precise statement of the theorem is that no stable equilibrium exists for a system of  $M$  competitors and  $N < M$  resources (MacArthur and Levins 1964).

<sup>10</sup> For a more comprehensive statement of this argument with reference to ethnic organization, see Hannan (1975).

forms. Consider the impact of licensing laws, minimum wage, health, and safety legislation, affirmative action, and other regulations on organizational action. When such regulations are applied to the full range of organizations in broad areas of activity they undoubtedly alter the size distributions of organizations. Most often they select out the smallest organizations. But it is not difficult to imagine situations in which medium-sized organizations (more precisely, those with some minimum level of complexity) would be more adversely affected. Besides altering size distributions, such regulations undoubtedly affect the diversity of organizational arrangements in other ways. Here one could analyze the impact of state action on the diversity of accounting systems within industries, curricula within universities, departmental structures within hospitals, etc. In each case it would be essential to determine whether the newly imposed constraint replaced lower level constraints, in which case diversity should decline, or whether the constraint cumulated with the existing constraints, in which case organizational diversity would be likely to increase.

To indicate the richness of the simple competition theory we have proposed we will briefly discuss another sort of empirical test. We noted above that research on regulation might concern itself with impacts on distributions of organizations by size. The classical model of organizational size distributions (Simon and Bonini 1958) proposes the following simple process. A number of organizations begin with the same small size. Some fraction are able to make or borrow some useful technical or organizational innovation that permits them to grow to some larger size. During some specified time period the process repeats itself with the same fraction making the innovation required to attain a larger size. Such a growth process eventually yields the lognormal distribution that characterizes so many size distributions.

Competition theory suggests a refinement of this classical model. If, as we argued earlier, large changes in organizational size are accompanied by structural changes (changes in form), organizations of very different size in the same area of activity will tend to exhibit different forms. As a consequence of these structural differences, they will tend to depend on different sets of environmental resource (and constraints). That is, within any area of activity, patterns of resource use will tend to be specialized to segments of the size distribution. This being the case, organizations will compete most intensely with similar size organizations. Also, competition between pairs of organizations within an activity will be a decreasing function of the distance separating them on the size gradient. For example, small local banks compete most with other small banks, to a lesser extent with medium-scale regional banks, and hardly at all with international banks. Under these conditions, significant alterations in the

size distribution indicate selection for and against certain organizational forms closely associated with regard to size.

Now let us return to the classical model. When large-sized organizations emerge they pose a competitive threat to medium-sized but hardly any threat to small organizations. In fact, the rise of large organizations may increase the survival chances of small ones in a manner not anticipated in the classical model. When the large organizations enter, those in the middle of the size distribution are trapped. Whatever strategy they adopt to fight off the challenge of the larger form makes them more vulnerable in competition with small organizations and vice versa. That is, at least in a stable environment the two ends of the size distribution ought to outcompete the middle (see below). So in a longitudinal analysis of organizational size distributions we would expect to see the number of medium-sized organizations decline upon the entry of larger organizations. Also, we would expect the fortunes of small organizations to improve as their competitors are removed from the environment. This reasoning holds generally for competition along a single gradient: those in the middle will be eliminated in stable environments (MacArthur 1972, pp. 43-46).

#### VI. NICHE THEORY

The principle of isomorphism implies that social organizations in equilibrium will exhibit structural features that are specialized to salient features of the resource environment. As long as the environment is stable and certain, we see no difficulty with this proposition. But does it hold when the environment shifts either predictably or unpredictably among several alternative configurations? Though the issues raised by attempting to answer this question are complex, doing so is crucial to developing adequate models of organizational-environment relations.

Intuition suggests that isomorphism holds as a good approximation only in stable environments. Faced with unstable environments, organizations ought to develop a generalist structure that is not optimally adapted to any single environmental configuration but is optimal over an entire set of configurations. In other words, we ought to find specialized organizations in stable and certain environments and generalist organizations in unstable and uncertain environments. Whether or not this simple proposition holds for social organizations, only empirical research will tell. However, a variety of population ecology models suggests that it is too simplistic. We cannot hope in one paper to develop fully the arguments involved. Instead we indicate the main lines of development with reference to one rather evocative perspective developed by Levins (1962, 1968): the theory of niche width.

The concept of "niche," initially borrowed by biologists from early

social science, plays a central role in ecological theory. This is not the place for an extended discussion of the multiple uses of the concept (see Whittaker and Levin 1976). The model which follows uses Hutchinson's (1957) formulation. From this point of view the (realized) niche of a population is defined as that area in constraint space (the space whose dimensions are levels of resources, etc.) in which the population outcompetes all other local populations. The niche, then, consists of all those combinations of resource levels at which the population can survive and reproduce itself.

Each population occupies a distinct niche. For present purposes it suffices to consider cases where pairs of populations differ with respect to a single environmental dimension,  $E$ , and are alike with respect to all others. Then relative competitive positions can be simply summarized as in figure 1. As we have drawn this figure, one population,  $A$ , occupies a

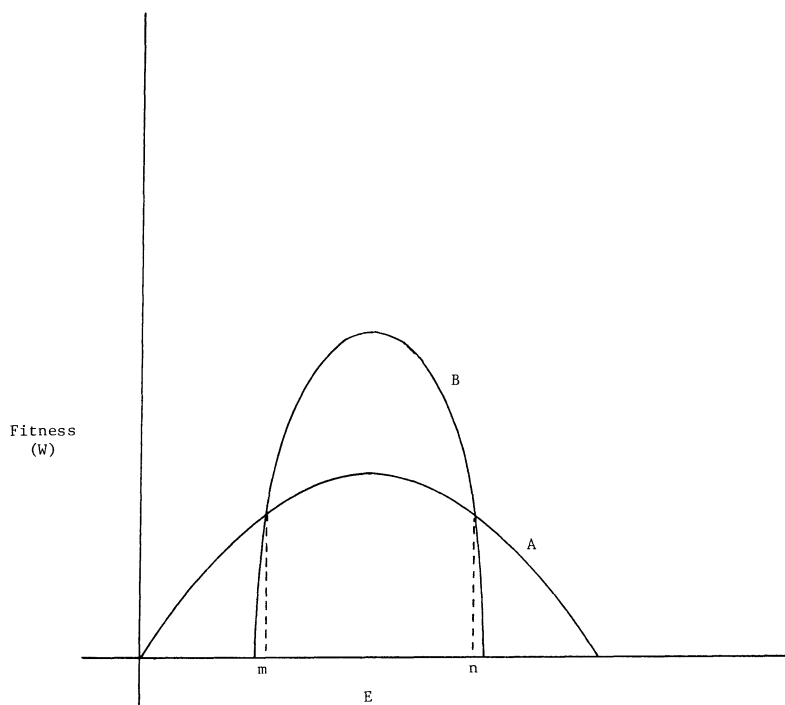


FIG. 1.—Fitness functions (niches) for specialists and generalists

very broad niche, whereas the other,  $B$ , has concentrated its fitness, denoted  $W$ , on a very narrow band of environmental variation. This distinction, which is usually referred to as generalism versus specialism, is crucial to biological ecology and to a population ecology of organizations.

In essence, the distinction between specialism and generalism refers to whether a population of organizations flourishes because it maximizes its exploitation of the environment and accepts the risk of having that environment change or because it accepts a lower level of exploitation in return for greater security. Whether or not the equilibrium distribution of organizational forms is dominated by the specialist depends, as we will see, on the shape of the fitness sets and on properties of the environment.

Part of the efficiency resulting from specialism is derived from the lower requirements for excess capacity. Given some uncertainty, most organizations maintain some excess capacity to insure the reliability of performance. In a rapidly changing environment, the definition of excess capacity is likely to change frequently. What is used today may become excess tomorrow, and what is excess today may be crucial tomorrow. Organizations operating in environments where the transition from state to state is less frequent will (in equilibrium) have to maintain excess capacity in a given allocational pattern for longer periods of time. Whereas those charged with assessing performance will be tempted to view such allocations as wasteful, they may be essential for survival. Thompson (1967) has argued that organizations allocate resources to units charged with the function of insulating core technology from environmentally induced disruption. So, for example, manufacturing firms may retain or employ legal staffs even when they are not currently facing litigation.

The importance of excess capacity is not completely bound up with the issue of how much excess capacity will be maintained. It also involves the manner in which it is used. Organizations may insure reliable performance by creating specialized units, as Thompson (1967) suggests, or they may allocate excess capacity to organizational roles, by employing personnel with skills and abilities which exceed the routine requirements of their jobs. This is one of the important reasons for using professionals in organizations. Professionals use more resources not only because they tend to be paid more, but also because organizations must allow them more discretion (including the freedom to respond to outside reference groups). Organizations, in turn, become more flexible by employing professionals. They increase their capacity to deal with a variable environment and the contingencies it produces. For example, hospitals and their patients often employ obstetricians and pediatricians in their delivery rooms even though the normal delivery of babies can be performed equally well, and perhaps even better, by midwives. The skills of the medical doctor represent excess capacity to insure reliable performance should delivery not be normal. Usually, the pediatrician examines the infant immediately after birth to see if there is any abnormality requiring immediate action. If the mother is suffering dangerous consequences from giving birth, and the child is also in need of attention, the presence of the

pediatrician insures that the obstetrician will not have to choose between them in allocating his attention.

Excess capacity may also be allocated to the development and maintenance of procedural systems. When the certainty of a given environmental state is high, organizational operations should be routine, and coordination can be accomplished by formalized rules and the investment of resources in training incumbents to follow those formalized procedures. If in fact the environment were unchanging ( $p = 1$ ), all participants were procedurally skilled, and the procedures were perfectly tuned, there would be no need for any control structure at all, except to monitor behavior. However, when certainty is low, organizational operations are less routine. Under these circumstances, a greater allocation of resources to develop and maintain procedural systems is counterproductive and optimal organizational forms will allocate resources to less formalized systems capable of more innovative responses (e.g., committees and teams). In this case, excess capacity is represented by the increased time it takes such structures to make decisions and by increased coordination costs.

The point here is that populations of organizational forms will be selected for or against depending upon the amount of excess capacity they maintain and how they allocate it. It may or may not be rational for any particular organization to adopt one pattern or another. What would seem like waste to anyone assessing performance at one time may be the difference between survival and failure later. Similarly, organizations may survive because high levels of professionalization produce coordination by mutual adjustment despite a somewhat chaotic appearance. Others, in which everyone seems to know precisely what he is doing at all times, may fail. Under a given set of environmental circumstances the fundamental ecological question is: which forms thrive and which forms disappear.

Generalism may be observed in a population of organizations, then, either in its reliance upon a wide variety of resources simultaneously or in its maintenance of excess capacity at any given time. This excess capacity allows such organizations to change in order to take advantage of resources which become more readily available. Corporations which maintain an unusually large proportion of their total assets in fluid form ("slack," in terms of theory of the firm; Penrose 1959; Cyert and March 1963) are generalizing. In either case, generalism is costly. Under stable environmental circumstances, generalists will be outcompeted by specialists. And at any given point in time, a static analysis will reveal excess capacity. An implication—shifting our focus to individual generalists—is that outside agents will often mistake excess capacity for waste.

We can investigate the evolution of niche width if we make the assumption that areas under the fitness curve are equal, and that specialists differ from generalists in how they distribute the fixed quantity of fitness over environmental outcomes. Specialists outcompete generalists over the range of outcomes to which they have specialized (because of the fixed level of fitness assumption). As long as the environmental variation remains within that interval (the interval  $[m,n]$  in fig. 1), generalists have no adaptive advantage and will be selected against. Alternatively, if the environment is only occasionally within the interval, specialists will fare less well than generalists. These brief comments make clear the importance of environmental variation for the evolution of niche width.

To simplify further, consider an environment which can take on only two states and in every period falls in state one with probability  $p$  and in state two with probability  $q = (1 - p)$ . Assume further that variations in environmental states are Bernoulli trials (independent from period to period). For this situation Levins (1962, 1968) has shown that optimal niche width depends on  $p$  and the "distance" between the two states of the environment.

To see this, we change focus slightly. Since each organization faces two environments, its fitness depends on fitness in the pair. We can summarize the adaptive potential of each organization by plotting these pairs of values (fitness in state 1 and in state 2) in a new space whose axes are fitness in each of the states, as in figure 2. In this representation, each point denotes the fitness of a distinct organizational form. The cloud of points is termed the "fitness set." We presume that all of the naturally possible adaptations are represented in the fitness set.

Our interest is in determining which points in the fitness set will be favored by natural selection. Notice first that all points interior to the set are inferior in terms of fitness to at least some point on the boundary of the set. In this sense the boundary, drawn as a continuous line, represents the optimal possibilities. Since natural selection maximizes fitness, it must choose points on the boundary. This narrows our search to seeking which form(s) on the boundary will be favored.

As figure 2*b* is drawn, no organizational form does particularly well in both states of the environment—no form has high levels of fitness in both. This will be the case when the two states are "far apart" in the sense that they impose very different adaptive contingencies on organizations. In such cases (see Levins 1968), the fitness set will be concave. When the "distance" between states is small, there is no reason why certain organizational forms cannot do well in both environments. In such cases, the fitness set will be convex, as in figure 2*a*.

The fitness functions in figures 2*a* and 2*b* describe different adaptive situations. The next step is to model the optimization process. To do so,

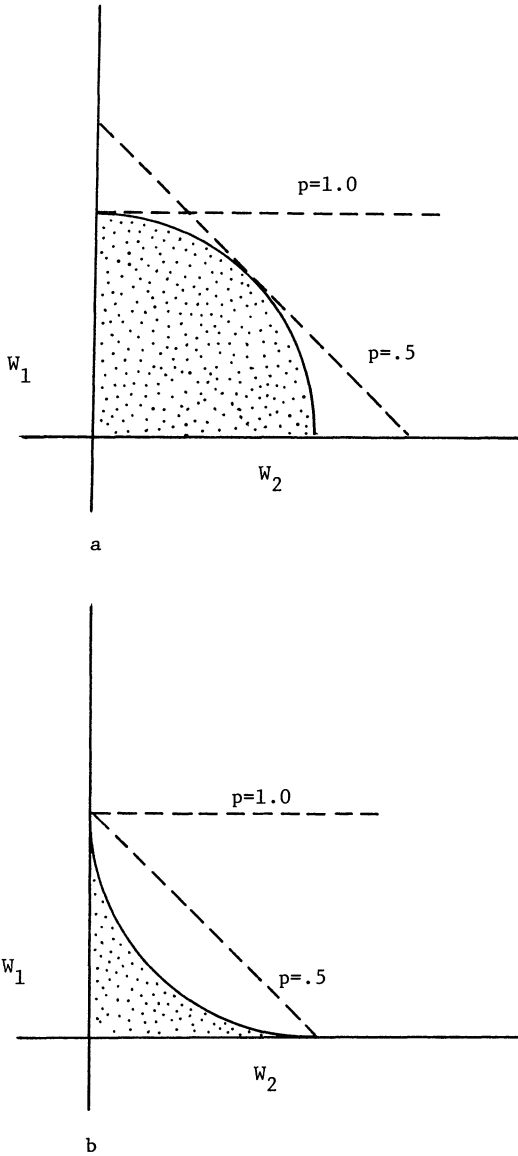


FIG. 2.—Optimal adaptation in fine-grained environment; *a*, convex fitness set; *b*, concave fitness set.

we introduce a further distinction. Ecologists have found it useful to distinguish both spatial and temporal environmental variation according to grain. Environmental variation is said to be fine-grained when a typical element (organization) encounters many units or replications. From

a temporal perspective, variation is fine-grained when typical durations in states are short relative to the lifetime of organizations. Otherwise, the environment is said to be coarse-grained. Demand for products or services is often characterized by fine-grained variation whereas changes in legal structures are more typically coarse-grained.

The essential difference between the two types of environmental variation is the cost of suboptimal strategies. The problem of ecological adaptation can be considered a game of chance in which the population chooses a strategy (specialism or generalism) and then the environment chooses an outcome (by, say, flipping a coin). If the environment "comes up" in a state favorable to the organizational form, it prospers; otherwise, it declines. However, if the variation is fine-grained (durations are short), each population of organizations experiences a great many trials and environment is experienced as an average. When variation is coarse-grained, however, the period of decline stemming from a wrong choice may exceed the organizational capacity to sustain itself under unfavorable conditions.

To capture these differences, Levins introduced an adaptive function to represent how natural selection would weight fitness in each state under the different conditions. In discussing fine-grained variation, we suggested that the environment is experienced as an average.<sup>11</sup> The appropriate adaptive function, then, simply weights fitness in the two states ( $W_1$  and  $W_2$ ) according to frequency of occurrence:  $A(W_1, W_2) = pW_1 + qW_2$ . In order to consider optimal adaptation we merely superimpose the adaptive function on the fitness set and find points of tangency of adaptive function and fitness functions. Points of tangency are optimal adaptations. The solutions for various cases are presented in figure 2. If the environment is completely stable (i.e.,  $p = 1$ ), then specialism is optimal. If the environment is maximally uncertain (i.e.,  $p = .5$ ), generalism is optimal in the convex case (when the demands of the different environments are not too dissimilar) but not in the concave case. In fact, as the model is developed, specialism always wins out in the concave case.

Consider first the cases in which the environment is stable (i.e.,  $p = 1$ ). Not surprisingly, specialism is optimal. The results for unstable environments diverge. When the fitness set is convex (i.e., the demands of the different environmental states are similar and/or complementary), generalism is optimal. But when the environmental demands differ (and the fitness set is concave), specialism is optimal. This is not as strange

<sup>11</sup> That selection depends on average outcomes is only one hypothesis. Templeton and Rothman (1974) argue that selection depends not on average outcomes but on some minimum level of fitness. Whether average outcomes or some other criterion guides selection in populations of organizations is open to question. We follow Levins in order to keep the exposition simple.

a result as it first appears. When the environment changes rapidly among quite different states, the cost of generalism is high. Since the demands in the different states are dissimilar, considerable structural management is required of generalists. But since the environment changes rapidly, these organizations will spend most of their time and energies adjusting structure. It is apparently better under such conditions to adopt a specialized structure and "ride out" the adverse environments.

The case of coarse-grained environments is somewhat more complex. Our intuitive understanding is that since the duration of an environmental state is long, maladaptation ought to be given greater weight. That is, the costs of maladaptation greatly outweigh any advantage incurred by the correct choice. One adaptive function which gives this result is the log-linear model used by Levins:  $A(W_1, W_2) = W_1^p W_2^q$ . The method of finding optimal adaptations is the same. The results are found in figure 3. Only one case differs from what we found for fine-grained environments: the combination of uncertain and coarse-grained variation with concave fitness sets. We saw above that when such variation is fine-grained, it is better to specialize. When the duration of environmental states is long, however, the costs of this strategy are great. Long periods of nonadaptation will threaten the survival of the organization. In addition, the fact that the environment changes less often means that generalists need not spend most of their time and energies altering structure. Thus generalism is the optimal strategy in this case as we see in figure 3*b*.

The combination of coarse-grained environmental variation and concave fitness sets raises a further possibility. The optimal adaptation in the face of environmental uncertainty possesses fairly low levels of fitness in either state. It seems clear that there must be a better solution. Levins discusses this case in depth and concludes that for the biological case with genetic transmission of structure "polymorphism" or genetically maintained population heterogeneity will be selected for. The suggestion is that populations combine types (differing, say, in color, blood type, etc.) some of which are specialized to state 1 and some to state 2. With such a combination at least a portion of the population will always flourish and maintain the genetic diversity which allows it to continue to flourish when the environment changes state. The set of all such heterogeneous populations (composed of proportions of specialists to each of the two environments) can be represented in the fitness diagrams as a straight line joining the most extreme points with all combinations falling within this line.

Coarse-grained and uncertain variation favors a distinct form of generalism: polymorphism. We do not have to search very far to find an analogous outcome. Organizations may federate in such a way that supra-organizations consisting of heterogeneous collections of specialist organi-

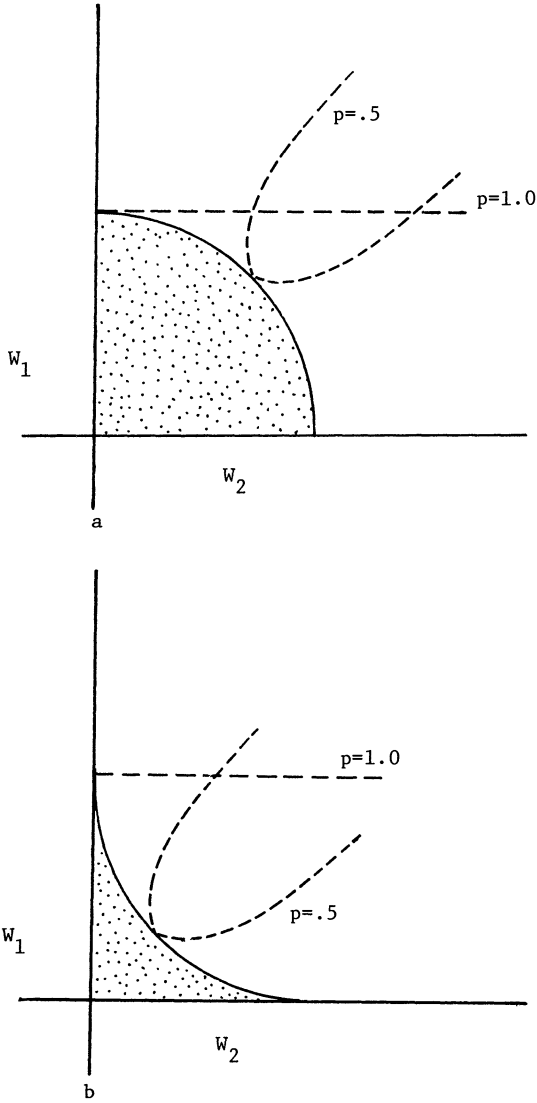


FIG. 3.—Optimal adaptation in coarse-grained environments; *a*, convex fitness set; *b*, concave fitness set.

zations pool resources. When the environment is uncertain and coarse-grained and subunits difficult to set up and tear down, the costs of maintaining the unwieldy structure imposed by federation may be more than offset by the fact that at least a portion of the amalgamated organization will do well no matter what the state of the environment. In terms of the model suggested above there are no other situations in which such

federated organizations have a competitive advantage. And even in this case, the only time during which they have such an advantage is when coarse-grained variation is uncertain.

Such an amalgamated "holding company" pattern may be observed in modern universities. Enrollment and research support wax and wane over time as do the yield on invested endowment securities and the beneficence of legislatures. Some of these resources follow predictable cycles. Others do not. But it is extremely expensive to build up and dismantle academic units. It is costly not only in money but also in the energies consumed by political conflict. Consequently, universities are constantly "taxing" subunits with plentiful environments to subsidize less fortunate subunits. It is common, for instance, for universities to allocate faculty positions according to some fixed master plan, undersupporting the rapidly growing departments and maintaining excess faculty in others. This partial explanation of the unwieldy structures that encompass liberal arts departments, professional schools, research laboratories, etc., is at least as persuasive as explanations that emphasize intellectual interdependence among units.

Much more can be said concerning applications of niche theory to organization-environment relations. We have focused on a simple version highlighting the interplay between competition and environmental variation in the determination of optimal adaptive structure in order to show that the principle of isomorphism needs considerable expansion to deal with multiple environmental outcomes and their associated uncertainty. The literature in ecology to which we have made reference is growing exponentially at the moment and new results and models are appearing monthly. The products of these developments provide students of organizations with a rich potential for the study of organization-environment relations.

Consider an example. In his analysis of bureaucratic and craft administration or production, Stinchcombe (1959) argued that construction firms do not rely upon bureaucratically organized administrative staffs because of seasonal fluctuations in demand. Administrative staffs constitute an overhead cost which remains roughly constant over the year. The advantage of the otherwise costly (in terms of salaries) craft administration is that coordination of work is accomplished through a reliance upon prior socialization of craftsmen and upon organization. Since employment levels can more easily be increased or decreased with demand under a craft system, administrative costs are more easily altered to meet demand.

The fundamental source of this pattern is the seasonal variation in construction. In ecological terms, the demand environment is coarse-grained. In addition, the two states defined by season are quite different, resulting in a concave fitness curve. Craft-administered housing construction firms are probably quite inefficient when demand is at its peak and

when the kind of housing under construction is standardized. In such situations, we would expect this form of organization to face stiff competition from other firms. For instance, in regions where housing construction is less seasonal, modular housing, mobile homes, and prefabricated housing are more likely to flourish and we would expect the construction business to be more highly bureaucratized.

Another variation in demand is to be found in the business cycle. While seasonal fluctuations are stable (uncertainty is low), interest rates, labor relations, and materials costs are more difficult to predict. Variations of this sort should favor a generalist mode of adaptation. That is, when environments are coarse-grained, characterized by concave fitness curves, and uncertain, populations of organizations will be more likely to survive if they hedge their bets by seeking a wider variety of resource bases. For this reason, we think, craft-administered construction organizations are frequently general contractors who not only build houses but engage in other kinds of construction as well (shopping plazas, office buildings, etc.). In comparison, modular housing is cheaper and the units are installed on rented space. Consequently, interest rates are less important. Since organizations producing this kind of housing do not employ craftsmen but use the cheapest and least skilled labor they can obtain, labor relations are less problematical. It may also be that their reliance on different materials (e.g., sheet aluminum) contributes to a lower level of uncertainty. In consequence, we would expect this form of organization to be more highly specialized in its adaptation (of course there are technical factors which also contribute to this as well).

Craft-administered construction firms are set up in such a way that they can adapt rapidly to changes in demand, and they can adapt to different construction problems by varying the mix of skills represented in their work force. Bureaucratically administered construction firms are more specialized and as a result they are efficient only when demand is high, and very inefficient when it is low. We also believe that they tend to be more specialized with regard to type of construction. Craft-administered organizations sacrifice efficient exploitation of their niche for flexibility. Bureaucratic organizations choose the opposite strategy. This formulation is an extension of Stinchcombe's and serves to show that his argument is essentially ecological.

## VII. DISCUSSION

Our aim in this paper has been to move toward an application of modern population ecology theory to the study of organization-environment relations. For us, the central question is, why are there so many kinds of organizations? Phrasing the question in this way opens the possibility

of applying a rich variety of formal models to the analysis of the effects of environmental variations on organizational structure.

We begin with Hawley's classic formulation of human ecology. However, we recognize that ecological theory has progressed enormously since sociologists last systematically applied ideas from bioecology to social organization. Nonetheless, Hawley's theoretical perspective remains a very useful point of departure. In particular we concentrate on the principle of isomorphism. This principle asserts that there is a one-to-one correspondence between structural elements of social organization and those units that mediate flows of essential resources into the system. It explains the variations in organizational forms in equilibrium. But any observed isomorphism can arise from purposeful adaptation of organizations to the common constraints they face or because nonisomorphic organizations are selected against. Surely both processes are at work in most social systems. We believe that the organizations literature has emphasized the former to the exclusion of the latter.

We suspect that careful empirical research will reveal that for wide classes of organizations there are very strong inertial pressures on structure arising both from internal arrangements (e.g., internal politics) and the environment (e.g., public legitimation of organizational activity). To claim otherwise is to ignore the most obvious feature of organizational life. Failing churches do not become retail stores; nor do firms transform themselves into churches. Even within broad areas of organizational action, such as higher education and labor union activity, there appear to be substantial obstacles to fundamental structural change. Research is needed on this issue. But until we see evidence to the contrary, we will continue to doubt that the major features of the world of organizations arise through learning or adaptation. Given these doubts, it is important to explore an evolutionary explanation of the principle of isomorphism. That is, we wish to embed the principle of isomorphism within an explicit selection framework.

In order to add selection processes we propose a competition theory using Lotka-Volterra models. This theory relies on growth models that appear suitable for representing both organizational development and the growth of populations of organizations. Recent work by bioecologists on Lotka-Volterra systems yields propositions that have immediate relevance for the study of organization-environment relations. These results concern the effects of changes in the number and mixture of constraints upon systems with regard to the upper bound of the diversity of forms of organization. We propose that such propositions can be tested by examining the impact of varieties of state regulation both on size distributions and on the diversity of organizational forms within broadly defined areas of activity (e.g., medical care, higher education, and newspaper publishing).

A more important extension of Hawley's work introduces dynamic considerations. The fundamental issue here concerns the meaning of isomorphism in situations in which the environment to which units are adapted is changing and uncertain. Should "rational" organizations attempt to develop specialized isomorphic structural relations with one of the possible environmental states? Or should they adopt a more plastic strategy and institute more generalized structural features? The isomorphism principle does not speak to these issues.

We suggest that the concrete implication of generalism for organizations is the accumulation and retention of varieties of excess capacity. To retain the flexibility of structure required for adaptation to different environmental outcomes requires that some capacities be held in reserve and not committed to action. Generalists will always be outperformed by specialists who, with the same levels of resources, happen to have hit upon their optimal environment. Consequently, in any cross-section the generalists will appear inefficient because excess capacity will often be judged waste. Nonetheless, organizational slack is a pervasive feature of many types of organizations. The question then arises: what types of environments favor generalists? Answering this question comprehensively takes one a long way toward understanding the dynamic of organization-environment relations.

We begin addressing this question in the suggestive framework of Levins's (1962, 1968) fitness-set theory. This is one of a class of recent theories that relates the nature of environmental uncertainty to optimal levels of structural specialism. Levins argues that along with uncertainty one must consider the grain of the environment or the lumpiness of environmental outcomes. The theory indicates that specialism is always favored in stable or certain environments. This is no surprise. But contrary to the view widely held in the organizations literature, the theory also indicates that generalism is not always optimal in uncertain environments. When the environment shifts uncertainly among states that place very different demands on the organization, and the duration of environmental states is short relative to the life of the organization (variation is fine-grained), populations of organizations that specialize will be favored over those that generalize. This is because organizations that attempt to adapt to each environmental outcome will spend most of their time adjusting structure and very little time in organizational action directed at other ends.

Stated in these terms, the proposition appears obvious. However, when one reads the literature on organization-environment relations, one finds that it was not so obvious. Most important, the proposition follows from a simple explicit model that has the capacity to unify a wide variety of propositions relating environmental variations to organizational structure.

We have identified some of the leading conceptual and methodological obstacles to applying population ecology models to the study of organization-environment relations. We pointed to differences between human and nonhuman social organization in terms of mechanisms of structural invariance and structural change, associated problems of delimiting populations of organizations, and difficulties in defining fitness for populations of expandable units. In each case we have merely sketched the issues and proposed short-run simplifications which would facilitate the application of existing models. Clearly, each issue deserves careful scrutiny.

At the moment we are frustrated at least as much by the lack of empirical information on rates of selection in populations of organizations as by the unresolved issues just mentioned. Census data are presented in a manner that renders the calculation of failure rates impossible; and little longitudinal research on populations of organizations has been reported. We do, however, have some information on rates of selection. We know, for example, that failure rates for small businesses are high. By recent estimates upwards of 8% of small business firms in the United States fail each year (Hollander 1967; Bolton 1971; see also Churchill 1955).

In part this high failure rate reflects what Stinchcombe (1965) called the liability of newness. Many new organizations attempt to enter niches that have already been filled by organizations that have amassed social, economic, and political resources that make them difficult to dislodge. It is important to determine whether there is any selective disadvantage of smallness not of newness.

We doubt that many readers will dispute the contention that failure rates are high for new and/or small organizations. However, much of the sociological literature and virtually all of the critical literature on large organizations tacitly accepts the view that such organizations are not subject to strong selection pressures. While we do not yet have the empirical data to judge this hypothesis, we can make several comments. First, we do not dispute that the largest organizations individually and collectively exercise strong dominance over most of the organizations that constitute their environments. But it does not follow from the observation that such organizations are strong in any one period that they will be strong in every period. Thus, it is interesting to know how firmly embedded are the largest and most powerful organizations. Consider the so-called Fortune 500, the largest publicly owned industrial firms in the United States. We contrasted the lists for 1955 and 1975 (adjusting for pure name changes). Of those on the list in 1955, only 268 (53.6%) were still listed in 1975. One hundred twenty-two had disappeared through merger, 109 had slipped off the "500," and one (a firm specializing in Cuban sugar!) had been liquidated. The number whose relative sales

growth caused them to be dropped from the list is quite impressive in that the large number of mergers had opened many slots on the list. So we see that, whereas actual liquidation was rare for the largest industrial firms in the United States over a 20-year period, there was a good deal of volatility with regard to position in this pseudodominance structure because of both mergers and slipping sales.<sup>12</sup>

Second, the choice of time perspective is important. Even the largest and most powerful organizations fail to survive over long periods. For example, of the thousands of firms in business in the United States during the Revolution, only 13 survive as autonomous firms and seven as recognizable divisions of firms (*Nation's Business* 1976). Presumably one needs a longer time perspective to study the population ecology of the largest and most dominant organizations.

Third, studying small organizations is not such a bad idea. The sociological literature has concentrated on the largest organizations for obvious design reasons. But, if inertial pressures on certain aspects of structure are strong enough, intense selection among small organizations may greatly constrain the variety observable among large organizations. At least some elements of structure change with size (as we argued in Section III) and the pressure toward inertia should not be overemphasized. Nonetheless we see much value in studies of the organizational life cycle that would inform us as to which aspects of structure get locked in during which phases of the cycle. For example, we conjecture that a critical period is that during which the organization grows beyond the control of a single owner/manager. At this time the manner in which authority is delegated, if at all, seems likely to have a lasting impact on organizational structure. This is the period during which an organization becomes less an extension of one or a few dominant individuals and more an organization per se with a life of its own. If the selection pressures at this point are as intense as anecdotal evidence suggests they are, selection models will prove very useful in accounting for the varieties of forms among the whole range of organizations.

The optimism of the previous paragraph should be tempered by the realization that when one examines the largest and most dominant organizations, one is usually considering only a small number of organizations. The smaller the number, the less useful are models that depend on the type of random mechanisms that underlie population ecology models.

Fourth, we must consider what one anonymous reader, caught up in the spirit of our paper, called the anti-eugenic actions of the state in

<sup>12</sup> From at least some perspectives, mergers can be viewed as changes in form. This will almost certainly be the case when the organizations merged have very different structures. These data also indicate a strong selective advantage for a conglomerate form of industrial organization.

saving firms such as Lockheed from failure. This is a dramatic instance of the way in which large dominant organizations can create linkages with other large and powerful ones so as to reduce selection pressures. If such moves are effective, they alter the pattern of selection. In our view the selection pressure is bumped up to a higher level. So instead of individual organizations failing, entire networks fail. The general consequence of a large number of linkages of this sort is an increase in the instability of the entire system (Simon 1962, 1973; May 1973), and therefore we should see boom and bust cycles of organizational outcomes. Selection models retain relevance, then, even when the systems of organizations are tightly coupled (see Hannan 1976).

Finally, some readers of earlier drafts have (some approvingly, some disapprovingly) treated our arguments as metaphoric. This is not what we intend. In a fundamental sense all theoretical activity involves metaphoric activity (although admittedly the term "analogue" comes closer than does "metaphor"). The use of metaphors or analogues enters into the formulation of "if . . . then" statements. For example, certain molecular genetic models draw an analogy between DNA surfaces and crystal structures. The latter have simple well-behaved geometric structures amenable to strong topological (mathematical) analysis. No one argues that DNA proteins are crystals; but to the extent that their surfaces have certain crystal-like properties, the mathematical model used to analyze crystals will shed light on the genetic structure. This is, as we understand it, the general strategy of model building.

We have, for example, used results that rely on the application of certain logistic differential equations, the Lotka-Volterra equations. No known population (of animals, or of organizations) grows in exactly the manner specified by this mathematic model (and this fact has caused numerous naturalists to argue that the model is biologically meaningless). What the equations do is to model the growth path of populations that exist on finite resources in a closed system (where population growth in the absence of competition is logistic and the presence of competing populations lowers carrying capacities in that system). To the extent that the interactions of populations of *Paramecium aurellia* and *P. caudatum* (Gause's experiment) meet the conditions of the model, the model explains certain key features of population dynamics and the relationship of environmental variations to structure. To the extent that the interactions of populations of rational-legal bureaucracies and populations of patrimonial bureaucracies also meet the conditions of the model, the model explains the same important phenomena. Neither the protozoa nor the bureaucracies behave exactly as the model stipulates. The model is an abstraction that will lead to insight whenever the stated conditions are approximated.

Throughout we make a strong continuity-of-nature hypothesis. We propose that, whenever the stated conditions hold, the models lead to valuable insights regardless of whether the populations under study are composed of protozoans or organizations. We do not argue "metaphorically." That is, we do *not* argue as follows: an empirical regularity is found to hold for certain protozoans; because we hypothesize that populations of organizations are like populations of protozoans in essential ways, we propose that the generalizations derived from the latter will hold for organizations as well. This is the kind of reasoning by which biological propositions have most often entered sociological arguments (e.g., the famous—or infamous—organismic analogy advanced by Spencer).

Instead of applying biological laws to human social organization, we advocate the application of population ecology theories. As we have indicated at a number of points, these theories are quite general and must be modified for any concrete application (sociological *or* biological). Our purpose has been twofold. First, we sketched some of the alterations in perspective required if population ecology theories are to be applied to the study of organizations. Second, we wished to stimulate a reopening of the lines of communication between sociology and ecology. It is ironic that Hawley's (1944, p. 399) diagnosis of some 30 years ago remains apt today: "Probably most of the difficulties which beset human ecology may be traced to the isolation of the subject from the mainstream of ecological thought."

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