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Resources and People: An Economic Perspective

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INTRODUCTION

Economics, as the science of choice, is fundamentally concerned with the study of the way in which humans decide to do this rather than that, or to use this resource in a certain way as opposed to a slightly different way. Or, why humans use one resource and not another. In this discussion we propose to develop a conceptual view of the choice process central to the way in which humans interact with the natural environment. Throughout we will be attempting to focus on particular resource-human interactions. We also will be concerned with the relationship of our conceptual approach to resource management issues "on the ground."

At the outset it is important to point out that the perspective we will present is not part of the mainstream of resource economics. That more usual approach tends to focus on natural resources as mere inputs into a production process that includes labor and man-made capital. The economic problem is considered to be one of determining the most efficient level of use of the factors of production--of which natural resources are but one type. Interesting complications are introduced by admitting that some natural resources are non-renewable and so the problem becomes transformed into one of determining the optimal intertemporal path over which the resource is driven to economic--if not physical--depletion. A second aspect of the conventional approach would be to view natural resources as the receiving medium for by-products of human activity. Here, the economic problem becomes one of weighing the benefits and costs of certain levels of discharge into the natural environment.

In contrast, our view draws one away from considering the optimal rate of use of natural resources--a question about which there is a great deal of analytical and emotional literature. Neither are we here concerned with the economically efficient level of discharges into the natural environment. Our purpose is, rather, to highlight the structure of man's interaction with the natural environment. We intend to develop a model of the structure within which humans make economic (and other) calculations of the sort that have been extensively analyzed in the conventional literature.

Let us then start with the obvious; man must eat, and must have access to certain materials and tools to facilitate that need, as well as to provide a range of creature comforts. It also is--or at least ought to be--obvious that man is a cost minimizer. That is, work has an implicit cost (called an opportunity cost) in the form of foregone leisure. The cost of laboring in the fields is, at bottom, the gain that could be derived by engaging in the next most preferred pastime--be it conversation with friends, or sitting alone under a tree. But of course the cost of leisure is seeing one's family ill fed and ill housed. Few choices are costless since each action we take possesses a correlate for which certain benefits and costs exist. If I do A, I may not do B; the benefits of A must be considered against its costs, plus the costs of not doing B. And the costs of not doing B are the benefits that could be enjoyed from B had it actually been undertaken, net of the costs of doing B and the costs foregone by not doing A.

While this all seems rather formidable, it is necessary to keep in mind that we make such choices daily, though we are often not conscious of the sorts of tradeoffs described above.

The second aspect of man is that change has its own costs--call it the psychic costs of the unknown. If doing A has been the tradition (habit) then switching to B will carry some costs--at least initially. The concept of a learning curve captures this notion of the costs of change. We start from the position that to consider choices is to consider change from the status quo, and that this process carries a special cost that must be considered.

A less uncontroversial aspect of our premise--though one that is reasonably secure--is that man makes explicit choices on the basis of information at his disposal. And if presented with exactly the same bundle of information and states of nature at two discrete points in time would make the same choices, assuming that preferences remained the same. This is rationality in its starkest form. If state of nature I exists and an individual chooses to do A, then rationality simply requires that when presented with the same state of nature an instant later the individual would not choose B. Finally, bounded rationality is simply a reflection that information to the decision maker is not unbounded, nor perfect, nor is it costless. There is an economically efficient level of information and we daily calculate whether or not an extra unit of information is worth the costs. To decide to seek no more information and to act on the basis of the available data (and to make the same choice when faced with the same data) is bounded rationality.

Let us be clear that rationality says nothing at all about man's relentless pursuit of profit. Rationality simply speaks to consistent behavior in the face of constraints (including information) as guided by an individual's utility (or preference) function. One individual may lie awake nights scheming to make more income, while another may engage in the same thought process to avoid as much work as possible (shirking). Both are rational given their preferences, though the latter may go hungry from time to time.

These behavioral assumptions are necessary for us to begin to construct a conceptual framework of how man interacts with an ecosystem in his daily pursuit of food and materials. The ultimate goal of any inquiry of this sort should be to derive testable hypotheses about the structure of institutional arrangements that govern: (1) control of natural resources; (2) the level and the incidence of the benefits of that use; and (3) the level and the incidence of the costs of that use. Ultimately, our interest lies in the interrelations between a social system and an ecosystem.

THE MODEL

A natural community is one in which undomesticated species of plants and animals evolve in some serial progression towards a climax ecotype. The very essence of man's interaction with an ecosystem is the process of arresting that progress so that the ecosystem produces those things of economic value to man; where "economic" does not mean to sell for profit, but means instead that as man economizes on that which is scarce (labor, information, and energy) he is able to extract from the ecosystem valuable objects. A climax community is one with very little interest to man in a direct material sense--though it may be quite nice to view as a tourist, and it may contribute significantly to long-run ecological stability.

Man comes into these natural plant and animal communities and begins to use a very small part--two or three of the hundreds of plants are edible and nutritious, and several of the animal species can be harvested at a net gain (yield in nutrition and material more than they cost to harvest). Of course, the ultimate extreme in this chain of events is when man finally eliminates much of the natural plant community and replaces it with a few species that have acquired--because of conditions to be developed in more detail below--tremendous economic value. Corn, wheat, and soybeans in the American midwest have virtually replaced a large number of plant species. Once that substitution has occurred, it too must be assiduously maintained--else nature will "take back the land."

Let us start with the idea of a "resource." This term is prominent not only in academic circles, but in practical management discussions as well. The adjective "natural" is often added, though there is often confusion about how much processing is required before a resource ceases to be a "natural" resource. But the more pertinent issue for us concerns the exact meaning of a "resource." In simplest terms, a resource is something with value to man--directly or indirectly. Coal and wood are resources, but so is solar energy, though it was only recently (since the advent of solar collectors) that it has been considered to be a natural resource that we can manage. However, plants are solar collectors and so we use solar energy embodied in plants.

The second aspect of a natural resource is that it can be controlled by humans. That is, man could control solar energy through its manifestation in plants, but he could not control the solar energy directly. So solar energy has always had tremendous economic value to man, but it was not a natural resource in the sense that it could be controlled (its access denied until the payment of a fee was offered). Now with marketable solar collectors it is possible to harvest and sell the sun's energy directly rather than as the embodied energy in a tree. Once this happens we begin to think of solar energy as a natural resource in the same category as energy from coal (former plants), or from wood (plants). In a sense, solar energy trapped by a collector represents a future source of energy as wood or as coal. Although it is not particularly scarce, such rays collected on one's roof means that a possible tree is without that energy.

This discussion is intended to make the point that a resource is defined by two aspects of the particular society under study--its technology, and its institutional structure. Gravel was not a building resource for the native Americans because the technology (knowledge and tools) for making concrete did not exist. Solar energy was not a natural resource for us in the direct sense until the technology appeared to make its capture and use on demand possible; and until the institutional arrangements for controlling it became common. These institutional arrangements, by the way, are still evolving; city zoning laws regarding the

blockage of a collector by a neighbor's trees are under consideration. The demand for the technology and the institutional arrangements has been stimulated by the apparent economy of solar energy vis-a-vis more conventional energy sources. This brings us to the third aspect of a resource.

Natural resources, because they do not exist outside of a particular technical and institutional milieu, are not defined once and for all, but rather "become" as institutional and technical conditions change (see Chapter 1). As new things become scarce and valuable, it becomes economical to change the way we do certain things. Part of the process of change is the recognition that new inputs are available. When those inputs become defined in such a way that they can be controlled, then a new natural resource has been created.

For completeness, we must consider those things that have not yet assumed economic value (that is, have not yet become resources), and those things that have a negative economic value (that is, are negative resources). We will call the first non-resources, and the second neg-resources. In a community of plants and animals, certain plants provide sustenance to the animals, and others are of no account to the animals. If man relies upon the animals for sustenance and materials, then not only are the animals a resource, but so are the plants that sustain those animals. Man manipulates the plant community to provide for himself directly, and for himself (indirectly) through the animals.

Those plants with economic value to man as processed by the animals are resources as much as are the plants that man uses directly. But there are some plants that are quite incidental to both man and animal; these are the non-resources. It could very well be the case that over time a non-resource could become a resource. Gravel, as mentioned previously, would be an example. Likewise, sand became a resource for making glass once that technology became known.

Let us now consider neg-resources. A neg-resource is something with negative economic value to the human enterprise--either directly or indirectly. Malaria and schistosomiasis are neg-resources, with the intense search for cures (preventative measures) at least having neutralized the impacts of the former. Indirect neg-resources would be plant diseases and animal diseases, or plants that are poisonous to valuable animals. A great deal of human energy is devoted to the enhancement of the contribution of resources, and to minimizing the contribution of neg-resources.

Before proceeding, it is worth discussing, if only briefly, the delicate balance that often exists between something being a resource (having positive value) and something being a neg-resource. If we leave aside momentarily the ground water implications of snow, it is a useful part of the ecosystem with which to make our point. In some parts of the world where snow falls, we see a human activity having evolved that creates considerable enjoyment for the participants (winter sports of various kinds), and considerable income for those who have managed to capture the economic rents from that enjoyment (ski-lift operators, other service establishments). Institutional arrangements exist such that only a few fortunate individuals can obtain a franchise to haul people up mountains, to groom ski trails, and to cater to their food and lodging needs. The franchise allows the capture of income streams from a naturally occurring physical entity (snow); snow is surely a resource.

But snow can also be a significant neg-resource. The amount of human time and financial resources devoted to its removal--and the social costs of accidents arising from those who try to walk or drive on it--mean that it is a neg-resource of some moment. Hence, we see that the same item, depending upon its location, amount, and human use, can be both a resource and a neg-resource. The distinction is seen to lie in the human effort that evolves to both benefit from it, and contend with it.

This recognition of the positive and negative attributes of the same basic physical object allows us to introduce the concept of "control centers." A control center is the locus of individual and collective choice exercised with respect to the use of a resource; we will see that there are a number of control centers in an economic system. The first of these will pertain to technical choices made with respect to the use of either plant or animal resources; we will exclude other types of natural resources (including snow) from the present discussion to permit a more streamlined explanation. That is, if we start with a restricted set of resources (plants and animals) we could develop the following:

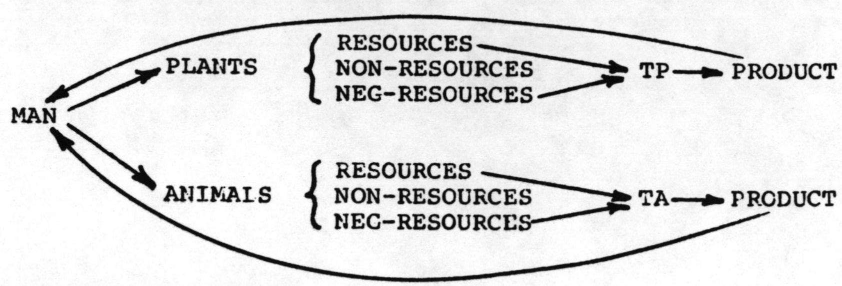

FIGURE 6.1 Resource control centers

Here we see the social system receiving the products of both plants and animals, with the control being exercised over both domains in terms of attempting to enhance the value of the resources, and minimize the impact of the neg-resources. The products that result are the outcome of a conscious choice process regarding the particular resources to be used, the particular neg-resources to be controlled, and the means for doing both. The means include both the technical aspects as well as the institutional aspects; we will refer to this as the techno-institutional structure. Let us consider an example. Working groups of the Arapesh in New Guinea that tend the sago palm are characterized by a particular institutional structure that determines work responsibilities, as well as the distribution of the harvest among a number of non-workers. We would say that this choice resides in control center TP. The hunting parties of traditional societies possessed extensive rules regarding responsibilities in the hunt, as well as rights to share in the kill. Here, we are concerned with control center TA.

Figure 6.1 is much too simple for the reason that it does not permit product flows to be redirected back to the resource base from whence they came, nor to a counterpart resource base. That is, man faces the choice of directing the product: (1) back to the same subsystem; (2) to the other subsystem; (3) to his direct use; or (4) as an intermediate input into a further production process. Consider the following examples. In the plant subsystem, leaves can be taken from the forest for fodder for livestock, in which case they become a direct input into the animal subsystem. It is also possible that the leaves might be cooked in water to make tea for direct human consumption. Or, the leaves might be used as fuel for a fire with which to cook other items. Finally, the leaves can be left in the forest to provide organic matter--which implies that they are an input back into the same subsystem from which they came.

In the animal subsystem, animal products such as milk can be consumed directly by humans, it can be used as an input to make a different product (cheese), or it can be fed to other animals (calves). Other animal products (dung) can be left on the land as an input to the plant subsystem, it can be used directly to "paint" a mud hut, or it can be burned to cook other foods. How the members of a social system choose to allocate the products of both the plant and animal kingdoms is determined at two separate control centers. On the plant side, there is an initial choice between allocating the product to the animal subsystem or reintroducing it into the plant subsystem. If it is to be taken out of the ecosystem, the choice must still be made whether or not it will be used directly--that is, is it a final good--or will it be processed in some way prior to human use (an intermediate good). We show this control center as P1 in Figure 6.2. On the animal side, a product can be returned to the animal subsystem, it can be directed to the plant subsystem, or it can go to man for either final or intermediate use. This control center is shown as A1 in Figure 6.2.

Also shown in Figure 6.2 are two other control centers (P2 and A2). For those product flows that are for intermediate use rather than for final use, it is possible for the product to be directed either back to the same subsystem from whence it came, or to man for further processing prior to ultimate use.

We have also labeled product flows in Figure 2 to illustrate the contribution from each resource. FPM+ represents the plant products destined for man's direct (final) consumption. Examples are berries, fruits, and plant materials used directly for, say, building construction (thatch). The flow of plant products for intermediate use can either be returned to the plant community (wood for a fence to control grazing use) or the flow can go to man for further processing (wood for conversion into cut lumber). The former flow is labeled IPP+, while the latter is labeled IPM+.

From the animal subsystem FAM+ represents the flow of animal products for man's direct (final) consumption. As indicated above this could be meat, milk, or hides for clothing. But certain products from the animal subsystem can be taken by man and directed selectively back into the animal subsystem (IAA+). An example would be animal products such as milk given to selected young animals, or it could be young animals themselves retained as part of the breeding herd. This choice is made at control center A2. Part of the intermediate product flow (IAM+) returns to man for further processing. An example of this flow would be animal products that are processed into leather and glue.

We have focused on positive flows from the plant and animal subsystems, but we must recognize that there are negative flows as well. One example of a negative flow is that arising because man manipulates the ecosystem (at TP or TA) to realize a greater product and by so doing creates negative impacts for the plant or animal systems (PA- and AP-). An example of a negative flow from the plant side of the system would be the destruction of habitat for crop production that then causes negative impacts on certain wildlife (PA-). Likewise the reliance on certain animal outputs (choices made at TA) causes a negative flow to certain parts of the plant subsystem (AP-). Overgrazing could

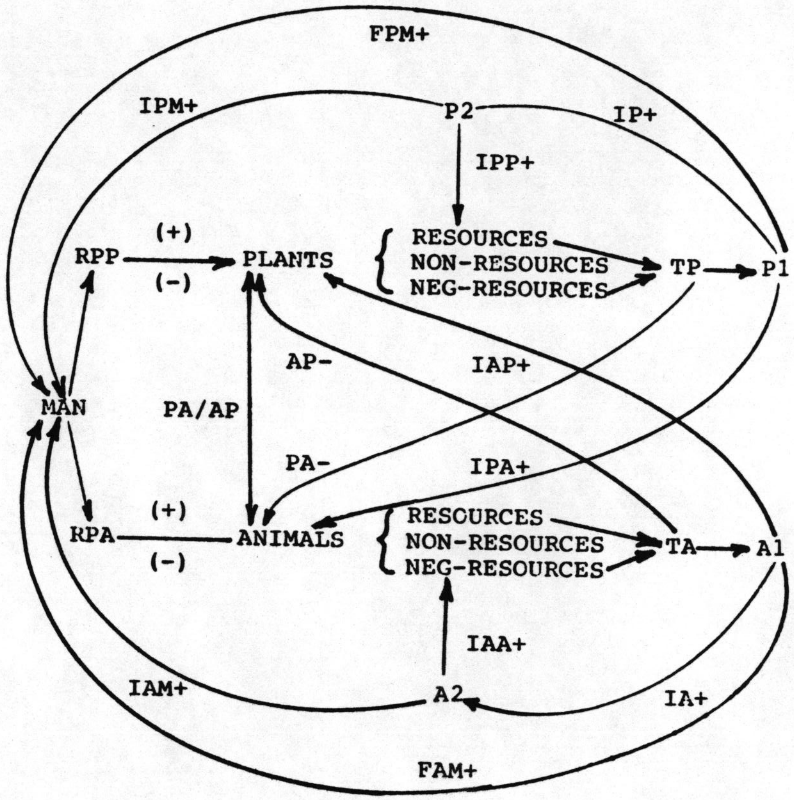

FIGURE 6.2 Resource control centers with sub-systems and feedback loops

be an example of this effect, but so would the specific choice of animal species that used only a portion of the plant subsystem.

Notice in Figure 6.2 the relation PA/AP (plant-animal/animal-plant). In essence this link represents the natural ecosystem before man's influence is brought to bear. That is, in terms of the figure, man's influence in the natural system is to control the vertical linkage between the plant and animal subsystems and to divert that linkage into an horizontal one monitored and manipulated at the various control centers.

The final control centers in Figure 6.2 are noted as RPP and RPA. In essence these are two primal centers that link man to the ecosystem, for it is here that there is a choice pertaining to both positive and negative impacts upon the two subsystems. The positive and negative flows linking these centers to their respective subsystems indicate that man can either enhance each subsystem, or can diminish it. Pollution that kills plants or animals would be an example of a negative impact. Technological change that alters the basic nature of the plant or animal subsystems is an example of a positive impact. Genetic manipulation of both plants and animals comes to mind.

We will now turn to a discussion of the way in which economic issues are considered in the context of resource use. This discussion will focus on the choices to be made at each of the control centers described above.

THE ECONOMICS OF CHOICE

Let us start with the clarification that the notion of a "control center" does not imply free-standing and autonomous locations where choices are made. We are simply disaggregating the many decisions that are made about resource management into several distinct decision points where the nature of the respective choices can be made clear. This allows us to concentrate on choices that pertain to the nature of the desired output from the ecosystem, the nature of plant and animal subsystems to be maintained (managed) by the social system, the choice of technique in utilizing those subsystems, and the choices regarding the degree of processing applied to the various products.

It is essential to recognize that the control centers being considered here are at an intermediate level in the institutional structure of the hypothetical society--they are subsidiary to the basic institutional structure, and they are above the level of choice at the individual household level. That is, any society consists--at the highest and most abstract level--of a constitution that specifies the general structure of interpersonal relations; who counts (one individual vis-a-vis other individuals), the individual vis-a-vis the state, and the rules (procedures) for changing the rules. The constitution and ancillary rules define individual rights, duties, obligations, privileges, and exposure to the rights and privileges of others. It is within this level that entitlements (property rules and liability rules) are specified and given protection [Bromley, 1978].

It is at this level that the broad outlines of political and economic power are specified. The rights of landowners to choose cropping patterns and labor-use arrangements are detailed at this level. The eminent domain clause in the U.S. Constitution protects the vegetable farmer from the taking of her land for an airport without compensation. But where is the protection for the displaced farm laborers? The Constitution recognizes only those income streams arising from land and capital equipment on that land--not from the possession of labor power.

Against this backdrop of basic social rules and conventions then, we come to a second level of institutional arrangements. The structure of ownership of land, input supply firms, marketing firms, futures markets, commodity exchanges, public land management agencies, and the like, define yet another component in the specification of the operating environment for firms and households. To the extent that this structure defines income and wealth positions for individuals, then it also is instrumental in specifying certain aspects of the demand for products--which then becomes a derived demand for particular resources. Consider the following example. If choice cuts of beef are the desired diet of the rich, then this creates a demand for a livestock industry that must rely on certain types of land. If this land is devoted to beef production instead of the production of corn and beans for the masses then this structure of demand will have a profound impact on resource (land) use patterns and prices.

In simple/traditional economies and social systems, these same forces are present, although the degree of social stratification is usually less pronounced than in more "advanced" capitalist systems. In the traditional setting each group/band/tribe is both a consuming and a producing unit, and the several control centers depicted in Figure 6.2 are not well differentiated. As the family supplants the group as the prime decision unit, there becomes some distinction that will eventually show up in more articulated control centers. Eventually, some families control land (and the plants and animals thereon), while other individuals control the availability of technology, and yet others regulate or control the positive and negative effects on the resource base indicated by RPP and RPA in Figure 2.

In the Swiss Alps we find family control of some lands (the valley land) and group control of the summer pastures. This institutional articulation is not some historical accident but rather grows out of a conscious choice given the physical and economic facts of the situation (Netting).

In Figure 6.2 we can make reference to the fact that as an economic system moves from the more traditional to the more "modern," a greater degree of control is exercised over the resource system (the ecosystem) and the flows PA/AP become of less significance. Part of this diminution shows up as less of the product of the two subsystems going to the other subsystem--going instead to (or through) the economic system. But another dimension is that there is less randomness in the PA/AP flow and more purposiveness. That is, as humans exercise ever more control over the ecosystem, the flows PA/AP become residuals that exist for a specific purpose.

Of course we must recognize that the apparent control over the ecosystem may be just that--apparent. The current debate over the sustainability of monocultures is focused on this question of the costs--and the certainty--of control. Only time, and more research, will settle the question.

The resource economist would be concerned with two crucial aspects of choice at each of the control centers: (1) the structure of incentives--i.e., the relative "prices"--that influence choice; and (2) who is able to make, or substantively influence, the choices. Let us turn to that consideration.

The Choice of Technique

Given that land is to be plowed, is it to be done by oxen or by tractor? Are plant and animal pests (neg-resources) to be controlled by chemicals, by natural predators, or by brute force? Is the harvesting to be by machine, or by hand? Are animals to be herded off of cliffs, to be trapped in nets, to be shot, or to be raised in confinement? Are fish to be caught with nets, with hooks, or to be brought to the surface with dynamite? While these alternative choices of technique seem rather stark as comparisons at any moment in time, the social system has options for structuring choice such that one approach is "efficient" while others are not. The choice of technique problem also entails the diversion of resource flows away from the PA/AP avenue and towards human use. And, at this point, there is a choice to be made regarding control of the other subsystem so as to enhance the productivity of the one under study. The flows PA- and AP- depict this influence.

The Product Mix

At the next step in the decision process, there is a conscious choice within each subsystem regarding the nature and extent of the contribution that will go to the other subsystem directly (IPA+/IAP+), the nature and extent of the contribution to go back to the subsystems indirectly (IPP+/IPA+), and the nature and extent of the contribution to go to humans directly (FPM+/FAM+) or indirectly (IPM+/IAM+).

The basis of this choice will be the nature of the contribution to one destination versus the nature of the contribution to its next best destination; opportunity cost again. If we eat the seed corn it cannot become the basis of next year's crop. If we drink the milk of the cow (FAM+) then it is unavailable to nourish the young animals in the herd and IAA+ is diminished accordingly. If plants are used by man then they become unavailable for animals and the flow PA is diminished accordingly. If cow dung is used by man to cook his food then it is unavailable to fertilize the fields and the flow AP is diminished accordingly.

At each control center, choices are made on the basis of apparent advantage at the moment, dictated in the large (and over the longer run) by the basic institutional structure in place that determines, for the most part, the relative "prices" attached to each possible use of a resource, a neg-resource, and a particular product. Another set of prices is, of course, relevant; the prices that attach to particular technical choices. Here we have in mind the relative cost of labor vis-a-vis tractors, or the relative cost of chemical control of pests versus the labor-intensive method. If labor is abundant and chemicals are scarce, then their respective prices will dictate the "efficient" choice. We emphasize the adjective efficient to remind the reader that efficiency is a concept without independent meaning; it is a function of the distribution of income and rights (Bromley, 1982b).

The Processing Choice

As indicated earlier, any economic system faces a choice in terms of the degree of processing to be applied to its products. That choice is here depicted at P2/A2 and it involves a decision about relative values of products going forward for human use as opposed to being returned to the subsystem as a positive contribution. The attractiveness of one particular choice vis-a-vis another will depend upon the comparative costs and gains from that allocation. Since, over time, those relationships change, we should expect to find shifts over time reflecting these changes. It also bears mention that new knowledge acts to reduce the costs of choice and so over time, as our knowledge of particular ecosystems increases, it becomes easier to make adjustments that are beneficial to humans.

The Resource Choice

Although we here discuss it last, the basic question to be addressed by the social system is the particular aspects of the plant and animal subsystems that will be used, and how those subsystems will be treated. Humans now obtain approximately 80 percent of their food supply from just 11 plant species (Loomis, 1976). Similarly, only a small fraction of the animal subsystem is used either by hunting wild species, or relying on domesticated ones. The economics of this choice is most complex, but it surely reflects the interplay of tastes, needs, and the ability and willingness to forego other things (opportunity cost again) to obtain certain parts of each subsystem. This is the demand side. On the supply side we have the ecological conditions that dictate what is available, but also the technical infrastructure (including knowledge) that indicates what it is economical to utilize.

The other dimension of the broader "resource policy" choice at RPP/RPA concerns social norms regarding the less positive impacts visited on the two subsystems from general economic activity. With more advanced technical knowledge the economic system can now deposit on both plant and animal communities a large number of debilitating and toxic residues that hold important implications for resource flows reaching TP/TA and P1/A1, and ultimately man.

The nature of the choices made at RPP/RPA are fundamental to general resource policy, and yet they reflect embedded entitlements that convey privileges, rights, duties, and exposures. The idea that there is an efficient level of pollution control is simply an admission that under the prevailing structure of property relations regarding whose interests count when it comes to the use of air and water, then one configuration of waste disposal will be considered "efficient" and all others will be "inefficient." The control center merely takes that institutional structure as given and becomes the locus of choice with the relative prices taken for granted.

By way of summary, it is important to distinguish between the static problem of choices regarding resource use at all four of the control centers on a "daily" basis, and those conscious social choices that

influence the more basic institutional structure on which relative prices rest. For instance, a land reform movement, by gaining control of that resource from one small subset of society, would permit a quite different set of plant and animal resources to be produced. This would call forth a whole new constellation of prices, and would imply a quite different technical configuration.

The economist must be equipped to work in the static world of daily choice, but also to recognize the dynamic aspects that will influence relative prices and costs. The institutional structure as defined by the constitution and the more operational rules and conventions concerning resource control will provide the foundation (and rationalization) for the specific sanctions and incentives that define the daily environment for choice; what the economist would call opportunity sets of firms and households, individuals and groups.

THE ECOSYSTEM AND THE SOCIAL SYSTEM

In essence, resource management is the manipulation of the ecosystem via control centers such that a certain output bundle is achieved. Norgaard makes the point that economic "development" is, in large part, the process of making the ecosystem less complex, and of making the social system more complex (Norgaard, 1981). Geertz (1962) refers to this effect on the social system as "involution." In the transition from hunter/gatherer to sedentary agriculturalist, and then to modern industrial society we have become more dependent on non-renewable resources (coal, minerals), and less dependent on renewable resources (wood). We have also found it necessary to direct the nature of ecosystem transition into one in which diversity gives way to uniformity; complexity is replaced by simplicity. The reason for this is that the human enterprise seeks to minimize the transaction costs of interacting with the ecosystem. A highly diverse ecosystem such as found in the Amazon can be represented as a highly "scattered" or "chaotic" ecosystem that demands great effort by man to channel its diverse elements and embodied energy to his advantage. A piece of land with a large number of different plant and animal species requires considerable diversification of the economic system to use and process this physical diversity. It is much more "efficient" to consolidate species so that a large piece of land is devoted to species A, another to species B, yet another to species C, and so on. Then, we can build the man-made counterpart to the ecosystem to use these locally uniform plant and animal resources. Corn can be grown here, and we can have the physical infrastructure to handle corn and its products. Cotton can be grown over there and again we can localize the special infrastructure for handling cotton and its products. Since the economic system demands the specialization of function in both man and machine, we find it "efficient" to force the ecosystem to specialize as well. The economic concept of regional comparative advantage is built on this imperative.

This process of molding the ecosystem to fit the imperatives of an economic order is not as innocent as the foregoing paragraphs seem to imply. This is especially so when, as history shows us, it is often an external colonial power whose economy is being served by the ecosystem transformation (Brockway, 1979; Bromley, 1982a; Kent, 1983). Again the concept of efficiency as used by the economist is meaningless without reference to a specific institutional structure. Put somewhat differently, there are an infinite number of efficient solutions--each one dependent upon the initial structure of property arrangements and wealth.

In a static sense the types of choices made at the respective control centers are quite marginal in nature. However, over time, the very choices made at the control centers will change. That is, modernization expands the choice set available at any of the control centers. At RPP it was only recently that herbicides, insecticides, and new genetic material were available. Prior to that time man simply selected from among the set of available species. The introduction of the cow at RPA held important implications for the social system (and the ecosystem) that absorbed it.

The colonial legacy throughout much of the world can be considered in Figure 6.2 as the introduction of a stronger social system overlaying the indigenous social system. This then introduces an entirely new set of tastes and preferences for parts of the native ecosystem and can upset not only the ecosystem, but the indigenous social system as well. The advent of plantation crops (banana, rubber, coffee, tea, sisal, and pineapple) in the tropics was a particularly striking form of this intervention. The colonial power forced important land-use changes on the indigenous social system, and also required a particular form of social organization (indentured servitude) to assure that the crops could be planted and harvested at exactly the correct time.

Much of colonial history focuses on the crops and animals that were developed, and ignores the social aspect in the colonial country and in the colonized country. Monetization of the local economy came with

colonization and this change alone introduced important changes further encouraging manipulation of the native ecosystem.

Because this volume is concerned with the relationship between man and the environment it is essential that we understand the structure within which choices about that relationship are made. The foregoing discussion is intended to present a particular method of viewing man's interaction with (and dependence upon) the ecosystem. The emphasis has been on disaggregating that relationship into only two parts of the ecosystem (plants and animals), and on four control centers. As such, these stylized facts, while oversimplified, provide a powerful mechanism for understanding human choices regarding the environment.

The positive and negative manipulation of the ecosystem at RPP/RPA is a "macro-level" choice, based upon some desired products at P1/A1. The flows FPM+/FAM+ and IPM+/IAM+ reflect demand-side considerations. The supply-side is shown as RPP/RPA and TP/TA; it is here that the size and the character of the productive "plant" is determined. The various product flows are partly a function of the ecosystem--one does not grow artichokes near the Arctic Circle, nor do we find caribou in the tropics. But within these general constraints, man constructs a social and economic system to permit him to "make a living" with some minimal level of effort.

Our interest in resource management ought to include a careful study of how different societies have structured this choice process. We know that the pastoral herders of east Africa have innovated an institutional structure for managing livestock in an extremely severe and variable ecosystem. If one suffers unexpected losses these are made up by other members of the group--with the total contribution from others diminished by the extent to which the stricken individual was guilty of poor judgement (Swift, 1977). Under traditional management arrangements herds would move when the water source was depleted--water, not vegetation was the binding constraint. Under this regime the vegetation was, in essence, protected by the ephemeral nature of the water in tanks and shallow wells. Livestock production was largely driven by the needs of domestic consumption and status to be derived from owning livestock. As external markets opened up with the advent of colonialism this locally driven system became subject to the new relative prices imposed from outside of the system (Bromley, 1982a). Livestock now had value apart from status and local consumption, and hence cash could be earned by accumulating ever larger numbers. As the numbers increased it became obvious that water was the binding constraint and, as is to be expected, investments in deeper wells and more tanks began to be made-- capitalized from outside or from a nascent merchant class (Swift, 1977). Before long one found more sophisticated wells, fences, cattle owners, wage herders, vaccination and hence more cattle, merchants, and overgrazing. A system of control that had operated with a modest degree of "success" over a very long period of time in the most fragile of ecosystems was broken by colonialism and external markets. In the sense of Figure 6.2 there were now two social systems attempting to use the single ecosystem. Decisions were being made at the four control centers with one particular set of tastes, preferences, and values in mind, but now there are two competing imperatives operating at the various control points. Little wonder that there is tension, conflict, and environmental degradation.

In mountain ecosystems, we see a stable pattern of institutional arrangements and control decisions that are fashioned to operate a food system across a range of ecotypes (Netting, 1977; Rhoades and Thompson, 1975). For certain parts of the ecosystem we find institutional arrangements that locate resource-use decisions in the family or the individual. In terms of Figure 6.2 it is the individual or the family that is operating at the various control centers. For other parts of the ecosystem such control resides in collective decisions. In the Swiss Alps the valley bottoms are held in private hands and decisions there are highly individualized. In the summer pastures (the alp) this is not the case. Here, collective decision making prevails and so different processes are employed at the control centers. We find a similar situation in Nepal. The essence of these systems is variable control as a function of the season of resource use--since the nature of the resource being used is a function of the season.

What we see in any system--but especially obvious in those in which different resources are under differential control--is the design of social arrangements to permit the capture of the largest possible net social dividend from different parts of the ecosystem. The approach developed here would enhance the study of these arrangements and processes by focusing attention on the real (as well as monetary) valued effects. The framework presented in Figure 6.2 is a reminder that no decision made at a control center is made in isolation from decisions made at the others.

In conclusion, a thoroughgoing economic perspective on man and the ecosystem would, of necessity, focus on several levels of institutional arrangements. The highest and most abstract level is concerned with matters of ultimate social control and the means for

arbitrating disputes among competing claimants. At the next level we find a more basic institutional structure. In terms of the above model, it is here that the basic configuration of control centers is determined. One important decision problem is that of ultimate control over natural resources-- that is, who is empowered to make allocative choices? Within this basic structure then, we finally encounter the operating rules where labor and capital allocations are made, where land is devoted to crop A rather than to B, where certain agricultural practices are chosen, and the like.

We do not need to enter the debate as to whether or not people are universally interested in "profit." It is quite enough to recognize that human effort carries an implicit cost in the form of foregone leisure, and that individuals uniformly attempt to conserve on their effort. Social organizations reflect the results of that process. The environmental problem is, in essence one of constantly watching for instances in which individuals and groups seek to shift certain costs to the ecosystem to avoid having to bear those costs directly. As tastes and preferences change, and as the technical means grow to shift ever more serious costs, the challenge to social innovation becomes greater. Some doubt that man is smart enough to avoid self destruction. Vested interests in the status quo, expressed primarily at the control centers in Figure 6.2, present a more serious threat than lack of knowledge. Careful study of the nature of the decisions made at the control centers is the obvious way to understand how vested interests influence resource use. And, from there we can begin to channel efforts to correct abuses--whether merely nuisances, or serious threats to human survival.

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Part 3

Multidisciplinary Problem-Oriented Approaches