The Problem of Scale in Community Resource Management

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ABSTRACT / Scale is a fundamental variable in most community resource management programs. This is true both in terms of scale as a management concept (i.e., local, regional, and national level management) as well as a mapping concept (i.e., units on the map per unit on the ground). Julian Steward, the father of human ecology, recognized as early as 1950 that social scientists have failed to develop methods for incorporating the effect of scale in their work. This article seeks to determine whether methods used in plant and animal ecology for assessing the effects of scale are applicable to community resource management. The article reviews hierarchy theory and multiple scales, two methods (one theoretical and the other practical) for dealing with problems that span many scales. The application of these methods to community resource management programs is examined by way of an example.

Scale is fundamental, albeit often unrecognized, in most resource management problems. This is true both in terms of scale as a management concept (i.e., local, regional, and national level management) as well as a mapping concept (i.e., units on a map per unit on the ground). For example, management strategies that are sustainable at the field or farm level (e.g., the use of pesticides and inorganic fertilizers) may not be sustainable when applied to the watershed or region. Similarly, it is difficult to translate studies of local resource management systems (e.g., water management, common property regimes) into national policies or to understand the effect of national policies on local processes. Methods for switching scales easily are not well developed. Complex rules of generalization are needed to convert the computerized representation of a simple feature like a coastline to a larger scale, and it is extremely difficult to convert to a smaller scale because detail must be added (ACSM 1989).

Community resource management programs operate on the premise that resources are managed best when the people affected by decisions participate in the design and implementation of these decisions, but finding common ground between government managers and local users of public-domain resources is difficult. Governments seek to improve the welfare of the district or nation, while villagers seek to survive as a community. Planners need data that have been aggregated by administrative areas (counties, provinces, planning regions), whereas villagers are concerned with the performance of households and the use of individual pieces of land. Bureaucrats feel pressure to expand quickly from localized pilot projects to broader regions and have difficulty in dealing with local idiosyncracies, while villagers are concerned only with the local project and their own idiosyncracies. To be sensitive to the various spatial perspectives from which nations and villages view their resource management problems, planners need to operate on different spatial (and sometimes temporal) scales and to exchange information among these levels.

KEY WORDS: Scale; Community resource management; Geographic information systems; Hierarchy theory

Ciramaeuwah Girang typifies a village participating in the social forestry program sponsored by the Indonesian State Forest Corporation (Perhutani). A majority of farmers in Ciramaeuwah Girang are landless or possess extremely small landholdings. These farmers rely on state-owned forest land to make up shortfalls in agricultural production. The social forestry program trained the local forest guard in community organization techniques. This forest guard has worked with the local farmers to design management plans that define the authority, responsibility, and accountability of forest users and the forest management agency. Management plans have been implemented for three sites, and farmer groups have taken responsibility for managing these lands.

As a result of this program forest–farmer groups in Ciramaeuwah Girang manage forests today that were until recently waste land, but from the national perspective many questions exist as to the usefulness of this approach. For example, how generalizable are the results from this village to other villages in West Java or the rest of the country? How do national level forest and economic policies affect land management in this village? Can the lessons learned from this village be used to design management plans for the broader region of West Java?

Four decades ago Julian Steward, the father of human ecology, made the following observations about the role of scale in community studies:

> Most studies . . . treat the community as if it were a primitive tribe—that is, as if it were a self-contained structural and functional whole which could be understood in terms of itself alone. Scholars are quite aware that any modern community is a functionally dependent part of a much larger whole; but in general they have not yet taken account of this larger frame of reference in community study. Individual communities are often studied as if the larger whole were simply a mosaic of such parts (Steward 1950, p. 22).

Steward went on to write:

> The ethnographic method is qualitative rather than quantitative. In general, it tends to deal with all the phenomena which are found within a locality. It is open to criticism not because of its lack of quantification but because it treats the local groups as if the larger society did not exist. This limitation of the ethnographic method is acknowledged by most investigators of particular communities, who recognize that their studies need to be related to a larger universe of social and cultural phenomena. There are few studies which attempt to show how the larger society affects the community under investigation; and there are no studies which undertake to conceptualize fully and in detail the relationship between the community and the larger whole (Steward 1950, p. 22).

Unfortunately, little has changed since the time Steward made these observations. Many community resource management programs focus on individual farms or households. Researchers and planners collect data on who owns what resources, how these resources are managed, and the costs and benefits of managing these resources, but household-scale data are not sufficient in and of themselves. The most obvious limitation of a household study is that the scale itself is not big enough for regional and smaller-scale undertakings. Broad-based resource management programs require something more than just an aggregation of individual site results; sites must be placed within a regional environment, economic policy, and program planning context.

Regional scale data are useful for working with larger-than-farm units of landscape analysis and design. Planners can conduct full-scale landscape planning exercises such as developing overall plans for managing a watershed, including detailed designs for rehabilitating the lands between farms. Alternatively, planners can examine attributes of land-use systems in different landscape zones and can determine whether opportunities exist for complementary production, for example hillside farmers selling firewood to fuel-scarce commercial farmers in valley bottoms (Raintree 1987). However, just as household-scale data could not be used to reach conclusions about a region, regional-scale data are not useful for making generalizations about a state or group of states. Questions concerning units larger or smaller than the region require different scales of analysis.

Ecologists studying a wide range of topics recently have begun to develop methods for recognizing the effects of scale on their work (Wiens 1989). This article seeks to determine whether the work done by plant and animal ecologists is applicable to problems of community resource management. This question is examined by way of an illustration from community resource management. The article begins with a discussion of hierarchy theory and multiple scales, two methods (one theoretical and the other practical) for dealing with problems that span many scales. The article then examines the application of these methods to community resource management programs by way of an example.

Hierarchy Theory and Multiple-Scale Approaches

Hierarchy Theory

Hierarchy theory was developed by ecologists (among others—Koestler 1967, 1969, Simon 1962, 1969, Allen and Starr 1982) to provide a theoretical basis for dealing with scale problems. The theory asserts that a useful way to deal with complex, multiscaled systems is to focus on a single phenomenon and a single time–space scale. By limiting the problem, it is possible to define it clearly and to choose the proper system to emphasize. The following discussion of this theory is based on O'Neill and others (1986) and O'Neill (1988).

Hierarchy theory begins by portraying a phenomenon of interest as a series of hierarchial relationships. Figure 1 shows the relationships between levels in such a system. The system of interest (level 0) is a component of some higher level (level +1). For example, if the object of study is an individual organism, in studying this object we discover reproductive structures and behaviors that are difficult to explain if attention remains limited to the single organism. Only by referencing the higher level, the population, can the significance of reproduction be explained.

The next step in studying the system is to divide level 0 into components forming the lower level (level −1). We study the level −1 components in order to explain the mechanisms operating at level 0. A mechanistic explanation ordinarily means that a phenomenon is the logical consequence of the behaviors and interactions of the lower level components.

Hierarchy theory thus dissects a phenomenon out of its complex spatiotemporal context. Our understanding of the phenomenon depends on referencing the next

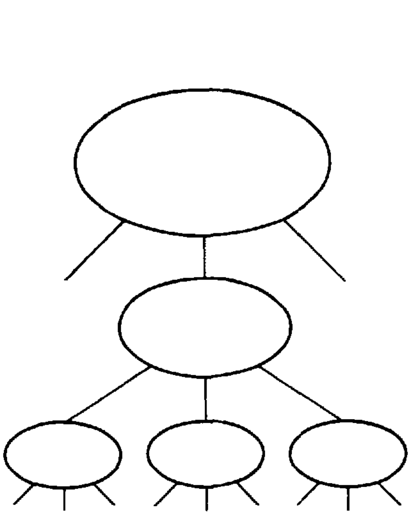

Figure 1. Schematic of hierarchy theory constraints. This approach may be applied to any level of scale. (Adapted from Dyer and Vinogrodov 1990, p. 20.)

higher and next lower scales of resolution. Levels higher than + 1 are too large and slow to be seen at the 0 level and typically can be ignored. Levels lower than − 1 are too small and fast to appear as anything but background noise in observations of level 0. In this way, the theory focuses attention on a particular subset of behavior and permits systematic scientific study of very complex systems. Starting from this introduction, let us try to apply hierarchy theory to community resource management problems.

Searching for the fundamental hierarchy. The theory recommends that we establish a hierarchy for studying complex systems. A caveat to this recommendation is that it is seldom fruitful to search for the one and only hierarchy because few single a priori criteria exist for developing this hierarchy. Instead, a number of different hierarchies may be used to address different problem areas. For example, consider dividing forest-use practices (level 0) into state variables (level − 1). One might consider a breakdown according to managers to be individuals, households, communities, districts, provinces, and nations. This division permits one to emphasize spatial and bureaucratic differences among forest managers. Alternatively, one might choose to stress the products and not the users. These might include firewood, fodder, grazing, timber, and agricultural conversion. There is no good reason to force all problems into a single framework.

Searching for the fundamental level. It follows from the preceding that it is not fruitful to designate the one and only level to which all other phenomena must be reduced. While most ecologists agree that environmental systems are multiscaled, some still attempt to reduce all of ecology to a fundamental level such as the population or ecosystem. In terms of community resource management, this is equivalent to trying to reduce all problems to the individual or household level. The phenomena of interest should determine the time and space scales emphasized by the researcher. This principal was recognized by Steward who wrote "where to draw the lines between levels (of organization) should depend more upon the particular problem under investigation than on any a priori logical construct" (Steward 1950, p. 114).

Translating principles between levels. Given that the system is scaled, what can we say about interactions between adjacent levels? In general it is not possible to transpose principles developed at one hierarchical level to higher and lower levels. Most concepts and models in ecology have been developed for a single scale. Yet this hidden assumption of scale is often ignored.

An example of transposition of scale was suggested by the example of pesticides and inorganic fertilizers. Farmers may use these products to increase the productivity of their crops. The farmer may see the beneficial consequences of these products in his fields and not be aware of the damage these products cause to lakes and downstream waterbodies. Management strategies that are sustainable at the field or farm level may not be sustainable when applied to the watershed or region.

In terms of community resource management, an example of this criterion is provided by our experiences with pilot projects. Community workers chosen to work with pilot projects are carefully screened and given intensive training. In addition, these workers often have access to higher-level decision makers and to resources that generally are not available. It seems logical that the lessons learned from these projects can be applied to regional and national programs. Numerous studies, however, have shown that without the care the pilot projects received, the expanded projects (broader scale) usually fail.

Effect of a higher level on a lower level. O'Neill (1988) argues that one of the most powerful insights of hierarchy theory deals with the concept of constraint. Simply stated, higher levels set constraints or boundary conditions for lower levels. Aquatic production relationships provide an example of how higher level constraints can determine system behavior. In nutrient-limited, freshwater systems, annual production is closely related to phosphorus loading. By knowing phosphorus levels, scientists can predict productivity without information about the species of phytoplankton involved in the process. Dynamics can be determined simply by knowing the higher level phosphorus constraints; detailed data on lower levels are not required. In terms of community resource management, this insight suggests that the effects on local communities of change in national policies, i.e., land tenure, subsidies, and taxes, can be predicted.

Predicting the higher level from the lower level. Because higher levels set constraints or boundary conditions for lower levels, hierarchy theory states that higher levels can be used to predict the outcome of a given event on the lower level. It is more difficult, however, to move in the opposite direction. Some higher-level properties are the sum or integral of lower-level systems; many are not. Stated as a general problem, the influence of lower levels on the higher is known as the aggregation problem. The problem is how to aggregate large-scale data in order to understand smaller-scale (regional and national) problems. The problem of aggregation becomes important for three reasons. First, we wish to take advantage of available large-scale information; second, it is sometimes useful to seek explanations at much larger scales; and third, we need to understand lower-level behavior to predict when unstable responses will occur.

This problem is of real importance because the most extensive information data bases are at large scales. For community resource management programs, the problem is how to utilize the data collected at household and village levels to make conclusions about the watershed, region, or nation. As previously indicated, Steward recognized over 40 years ago that the larger society could not be studied as if it were simply a mosaic of community studies (Steward 1950, p. 22).

Among the conclusions we can draw from hierarchy theory, the following appear to be useful for community resource management programs. First, the theory leads us away from the naive mistake of searching for a fundamental hierarchy or level of analysis. The theory suggests that we must consider different ways of structuring the data we collect and choose the hierarchy and level of interest according to the problem at hand. Second, the theory suggests that we can predict the influence of higher levels on lower levels. If we know something about a national or regional level phenomenon, we can predict the effect of that phenomenon on the local level. The opposite, however, is not true. Higher-level phenomena are not just the sum or integral of lower-level systems. This conclusion suggests that we must examine carefully how we utilize the large-scale data we collect from individual households and communities to make generalizations about the broader region or nation. The theory also suggests that large scales change so quickly as to be irrelevant to what happens at smaller scales. Does this suggest, for instance, that in some cases we can ignore what is happening to the individual and concentrate on the household or community? Finally, the theory suggests the situation changes dramatically when the system becomes unstable. Now the large-scale dynamics are unconstrained and tend to change the system drastically. However, there is no theory available to predict exactly which large-scale processes will be most important.

Multiple-Scale Hierarchical Approaches

About the same time that ecologists were developing a theoretical basis for dealing with scale problems, geographers and other land-resources specialists were developing a practical approach for representing environmental processes in a series of hierarchically arranged scales. Stone (1972) describes the multiple-scale approach as the division of data on a given topic or area into significantly different groups by the scales of information needed to describe, analyze, and present various distributions of data. The principal goal of this approach is to determine the number of scale classes to be used and the limits of each class. Scale classes depend on field observation, analysis of the data collected at various scales, careful comparison of these data with those available from other sources, and selection of the smallest scales wherein faithful generalizations may be made toward the initial objective of the study. Experience plays a major role in determining the amount of time and expense necessary for delimiting meaningful scale divisions, but the thrust of this approach is to develop a methodical procedure that guarantees consideration of all scales.

Stone argues (correctly in light of hierarchy theory) that it is a delusion to assume that large-scale study in the field can add up to small-scale conclusions in the office. Those conclusions must be reached through observation and mapping at smaller scales. Consequently, Stone recommends a hierarchy of scales minimally consisting of three levels such as regional (perhaps 1:500,000–1:200,000), sectional (1:200,000–1:75,000), and local (1:75,000–1:15,000).

Scientists from other natural resource-related disciplines (e.g., ecology, botany, soils, and forestry) also favor a multiple-scale approach progressing from the general to the particular, in other words small-scale surveys followed by more detailed studies (Steele 1967, UNESCO 1973, Druffel 1977). In addition to these studies, which are directed to particular components of the land surface (disciplines), there is also a well-developed landscape science that attempts to find naturally occurring environmental units that can be recognized, described, and mapped in terms of the total interaction of the attributes under study (Naveh and Lieberman 1984, Forman and Godron 1986). Within these natural units there is supposed to be a recognizable, unique, and interdependent combination of the environmental characteristics of landform, geology, soil, vegetation, and water (Christian and Stewart 1968, Rowe and Sheard 1981, Bailey 1983).

Perhaps one of the best known systems for dividing a landscape into homogeneous units is integrated land surveys (Christian 1958). Integrated land surveys divide landscapes into units and systems. A land unit is an area of similar genesis as defined by topography, soils, vegetation, and climate. A land system is an assembly of land units that are geographically and genetically related. These concepts can be applied at any scale and can be adjusted to the complexity of the landscape while maintaining their logical relationship to each other. Thus, working on a small scale, land units may represent gross land forms, such as mountains, valleys, alluvial plains, or plateaus, grouped according to their geomorphological relationships into land systems. On an intermediate scale, these units may become the land systems, with the various slopes and aspects of the mountains or valleys, the various kinds of alluvial deposits of the flood plains, or the units of microtopography of the plateau, as the land units. On a large scale, further subdivision of parts of these units would provide the land units, and the survey would approach in nature a combination of a detailed ecological and soil survey, the land unit maintaining its character as a recurring topographic unit together with its characteristic soils and vegetation.

In spite of minor differences among the various landscape classification systems, a general parallelism is evident in the occurrence of distinguishable units of landscape and of ranking these in a hierarchy (Christian and Stewart 1968). These multiple-scale hierarchically arranged frameworks have emerged for a number of reasons. First, they make it possible to plan projects in an orderly and selective manner. Second, they serve as a guide to where and how widely the results obtained from investigations at one location or local experience may be expected to apply (thus solving the aggregation problem). If an agricultural experiment is conducted on a sample site, or a successful land use has been achieved, the results can be expected to apply to other occurrences of that type of site. However, different sites, even though apparently similar in many respects, must be suspected of responding differently until proved by trial to do otherwise.

Finally, a multiple-scale hierarchical framework provides a common basis of sampling for subsequent studies. Where data are to be collected for statistical, economic, education, health, biological, or other equally divergent purposes, there is an advantage if the geographic unit used for sampling is common to each.

The multiple-scale hierarchical framework provides a guide for addressing issues of scale (both temporal and spatial) and begins to answer specific questions. Answers suggested by the framework include the following. Because information is scale-specific and data collected at one scale should not be used to make conclusions about phenomena occurring at different scales, it is usually necessary to use multiple scales to describe any environmental process completely. The number of scale classes and the limits of these scales depend on the phenomenon of interest. While determining the appropriate scale classes forms a major subject of investigation, scientists from different disciplines recommend the use of three scales, for example large, intermediate, and small. As suggested by hierarchy theory, small-scale data can be used to make predictions and hypotheses about larger-scale events. The reverse, however, is not always true. Hence, when it is necessary to make small-scale conclusions based on generalizations from large-scale data, researchers should assess the accuracy of the conclusions carefully.

The problem with this approach is the arbitrariness with which the multiple scales are chosen. In most examples, the definition of the different scales makes intuitive sense and the analyses reveal the scale dependency of patterns, but the scales chosen for analysis are still arbitrary. We need nonarbitrary, operational methods of defining and detecting scales. Wiens (1989) argues that statistical approaches, based on the observation that variance increases as transitions between scales are approached in hierarchial systems, and fractals (Mandelbrot 1983) may be useful for identifying the boundary of a scale domain.

Community Resource Management

To demonstrate that insights from hierarchy theory and multiple scales are useful for dealing with scale issues in community resource management programs, let us return to the questions raised in the introduction about the social forestry project in Ciramaeuwah Girang. We will examine the questions one at a time.

Are Results from This Village Valid in Other Villages in West Java or the Rest of the Country?

This question and other questions, such as whether future village studies have to be equally labor intensive, and whether lessons learned from other parts of the country can be applied in this village, focus attention on the transferability of village level studies. Both hierarchy theory and multiple scales suggest that the results from Ciramaeuwah Girang are valid only in villages with similar environmental and social constraints. The question thus becomes one of methodology—how do you classify villages into relatively homogeneous units?

To answer this question we turn to another project. The East Java agroecosystems project sought to identify relationships between land degradation and traditional land-use practices and to help farmers identify methods for improving the performance of their existing land-use systems.

The project began by manually identifying and classifying land units on Landsat images (1:250,000) (Fox and Suharsono 1986). Land units are areas where physical parameters, such as position in the landscape, slope, soil type, and depth, are similar (Christian 1958). These images provided a framework from which the project could choose sites for more detailed analysis. False-color infrared aerial photographs taken in 1981 (1:30,000) were acquired for the three sites chosen from the Landsat images. Photo interpreters reclassified the original land units into more detailed groupings and mapped land cover and land dissection. Land dissection reflects past susceptibility to erosion processes and does not necessarily reflect current erosion problems.

An interdisciplinary research team then chose several villages as being representative of the land units mapped on the aerial photographs. Team members made numerous short visits to each of these villages in groups of two or three people. These groups used rapid rural appraisal techniques to collect information from farmers on land and land-use practices. Interviews focused on basic needs—food, fuel, water, shelter, raw materials for local industry, cash, savings and/or investment, and social production. The interviews sought to identify the locally relevant forms of needs satisfaction (e.g., cassava and corn rather than rice, firewood rather than charcoal) and to describe the location, technology, resources, and activities involved in the production of the desired outputs (Fox 1989).

After completing the village studies, team members met with local farmers and discussed the physical, use, and socioeconomic characteristics of each land unit. This discussion resulted in the 15 land units being reduced to three agroecological zones (large areas where physical properties, cropping patterns, and socioeconomic variables were relatively similar). For each agroecological zone, questions were raised about factors constraining current production levels or affecting land degradation.

An example of these agroecological zones is the limestone hills along the south coast of East Java (Semaoen and others 1985, Fox and Suharsono 1986). These hills range in elevation from sea level to 500 m. The major crops grown include cassava and corn as well as fruit, nut, fodder, and firewood trees. Crop production is low because of limited soil fertility and severe water shortages during the long dry season. Farmers keep livestock, primarily cattle and goats, but these are of limited commercial importance. The farming systems found in these hills are fairly stable, as traditional crops are resistant to pest and disease vectors, and the small degree of commercialization protects farmers from price variations.

Because of low productivity, farmers in this zone are reluctant to invest in soil-conservation measures such as bench-terracing. Limited land capability and low cash incomes also severely constrain investments in commercial adventures. With the exception of limited use of inorganic fertilizers on staple crops, farm technology and socioeconomic conditions in this zone have been relatively static during the last decade.

Farm holdings in this zone are concentrated in small, owner-operated units, and absolute landlessness is low. Nonfarm employment growth has been slow. The refinement of limestone offers job prospects, but local deforestation constrains the necessary supply of firewood. Because of limited local economic opportunities, seasonal and permanent out-migration constitute the principal source of cash income in this zone.

The Agricultural Extension Service of the East Java provincial government used the findings from this project to design extension services that are sensitive to the physical environment as well as the cultural preferences of the farmers.

Before the results from the social forestry project in Ciramaeuwah Girang can be generalized to other villages in Java or the outer islands, a study such as the one described for East Java needs to be conducted. The East Java project used small-scale data to classify the environment into relatively homogeneous units. These data provided a framework for choosing sites from which to collect larger-scale socioeconomic data. The data collected at the large scale, however, were also used to redefine the small-scale units into three agroecological zones. Thus the East Java project differs from hierarchy theory in that it suggests that the solution to the scale problem is a reiterative and not a simple linear process. This reiterative process begins with a general understanding (small scale) of a phenomenon, moves to a more detailed (large scale) understanding, and then the knowledge gained in the large-scale study is used to redefine the original classification developed in the small-scale process. Results from Ciramaeuwah Girang can be transferred to other villages within the same homogeneous unit. More intensive fieldwork, however, is needed before these results can be transferred to villages in units with different environmental or cultural constraints.

How Do National-Level Forest and Economic Policies Affect Land Management in This Village?

Hierarchy theory suggests that higher levels set constraints or boundary conditions for lower levels. We can attempt to apply this principal to community resource management. For example, national land-use policies set constraints for the successful implementation of community level projects. Policies that reward participants for cooperating with resource management programs have a chance for success. Policies that do not provide incentives for cooperation through recognizing the rights and obligations of resource users invariably fail. The State Forest Corporation (Perhutani) manages state forests in the three provinces of Java. A recent Perhutani policy to allow farmers participating in social forestry programs to interplant high-value crops such as mango and durian on state forest lands solicited the cooperation of farmers in Ciramaeuwah Girang with this project. A more recent Perhutani decision to aggressively destroy rubber trees planted on state forests, however, has predictably met with resistance and the destruction of the cooperative spirit between the forest department and the local community.

Can Lessons Learned from This Village be Used to Design Provincial or National Management Plans?

This question focuses on the problem of data aggregation. We would like to be able to use the extensive experience gained and the data collected in Ciramaeuwah Girang to design management plans for the whole province of West Java and broader regions. Unfortunately, both hierarchy theory and multiple scales state that it is difficult to make predictions about the higher level based on information gathered at the lower level. Higher-level phenomena are not just the sum or integral of lower-level systems. This conclusion suggests that we must carefully analyze how we utilize the data collected from Ciramaeuwah Girang to make generalizations about the broader region or nation. No conceptual framework exists for integrating information of complex and detailed large-scale phenomena into simple and tractable models of small-scale systems (Woodmansee 1988).

The Role of Computers

Computer software exists for representing complex spatial relationships; this software may assist planners to overcome many scale-related problems. The ability to change the scale of a display is one of the more immediately attractive features of computerized mapping systems or geographic information systems (GIS). The data contained in computer-generated maps, however, remain scale-dependent; in other words scale and spatial resolution are established by the scale of the input document. Complex rules of generalization are needed to convert the computerized representation of a simple feature like a coastline to a smaller scale, and it is extremely difficult to convert to a large scale in an appropriate way. As a result, computerized data bases must include multiple representations (multiple scales) of the same geographical feature (ACSM 1989).

The usefulness of computers lies not so much in the ability to change scales, but in the ease with which spatial patterns can be analyzed. For example, if we want to study a regional phenomenon, we know intuitively to use small-scale data, but is 1:1,000,000 or 1:250,000 more appropriate for the phenomenon of interest? Computers and spatial statistics can play a role in quantifying the usefulness of different scales for studying specific patterns. Such methods do not remove scale as a variable (do not make data independent of scale), but they help researchers identify the scale at which a particular process contributes most to the formation of a spatial pattern.

Likewise, once we identify a scale for studying a given phenomenon, there are different ways in which we can aggregate the data to form a classification scheme (soil, vegetation, etc.) or to model an event. A potential advantage of computerized mapping systems is that maps of terrain variables can readily be weighted and combined to display new or refined classification systems. Such flexibility is important because no single land classification is optimal for all applications.

Another advantage of computerized mapping systems is storage. Scientists find data stored in a raw unprocessed form more useful for a number of different purposes than data stored in a generalized format, but in the past data collected for making maps have been lost or have been unavailable for use by other scientists because of storage problems. A computerized mapping system makes it possible for the scientist to map the locations from where data were collected and to save the details of the data in an attribute file. Other scientists can then analyze these data according to their own needs. As computer storage capacities grow, researchers will be able to store increasing amounts of data in a raw or unprocessed format, making it possible to classify data in ways that more accurately reflect the phenomenon of interest.

Conclusions

This article examines the issue of scale in community resource management problems. Scale problems arise out of the fact that information is scale-specific. Consequently, scientists recommend the use of multiple scales to describe any environmental process completely. This is true even with computerized mapping systems because the data contained in these systems remain scale-dependent. Useful scale classes depend on objective and complete field observation, careful analysis at various scales in comparison with data from other sources, and selection of the smallest scales wherein faithful generalizations may be made. Experience plays a major role in determining useful scale divisions. Consequently, the process of defining scale classes remains more of an art than a science.

Hierarchy theory suggests that using small-scale data (upper level) to make predictions about large-scale events is more accurate than the reverse. Similarly, most geographers and land managers working with multiple-scale systems favor a stage-by-stage approach for obtaining land resource information, progressing from the general to the particular, in other words, reconnaissance surveys followed by more detailed studies. Scientists favor this approach because, among other reasons, the small-scale data provide a sampling framework for subsequent large-scale studies. No conceptual framework exists for the reverse process—integrating information of complex and detailed large-scale phenomena into simple and tractable models of small-scale systems. When it is necessary to generalize large-scale data to make conclusions at a smaller scale, extra effort must be made to assess the accuracy of the conclusions.

Computerized-mapping systems provide valuable assistance in analyzing similarities and differences among data bases within a given scale and between scales. This assistance makes it possible to begin to quantify the differences between different methods of defining scale classes. Another contribution computerized-mapping systems make to solving the scale problem is the ability to store extensive data sets. This capacity makes it possible to store original data and sampling points.

What do these conclusions mean in terms of the questions raised at the beginning of this paper about the usefulness of community resource management programs to national level planners? Hierarchy theory and multiple scales suggest that conclusions reached at one scale can only be applied to other problems posed at the same scale. In other words, the experience gained from Ciramaeuwah Girang may not be useful for designing national social forestry policies, but this experience may be useful in other communities with environmental and cultural conditions similar to those found in Ciramaeuwah Girang. The knowledge gained from a specific community can only be applied to other communities if the researcher has already developed a small-scale classification of the broader region. Generalizations can be made among communities within the same class, although these generalizations should be examined closely.

National policies for guiding social forestry programs require data collected at a level that reflects the variance found throughout the country. Once such policies are designed (for example, national-level policies affecting social forestry, price, land tenure, and forest management) planners should examine the effect of these policies on specific villages and individual farmers. Likewise, scientists should study the effect of farm-level management strategies (such as the use of pesticides and inorganic fertilizers) not only on the farm but also at the broader scale of the watershed and the region. When scientists and planners recognize scale for the fundamental role it plays in resource management programs, terms such as top-down and bottom-up become meaningless. Because information is scale-specific, it is necessary to use multiple scales to describe any environmental process completely. Both top-down (small scale) and bottom-up (large scale) approaches are necessary for formulating and solving resource management problems. These conclusions apply whether the phenomena of interest are community resource management projects or global ecological processes.

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