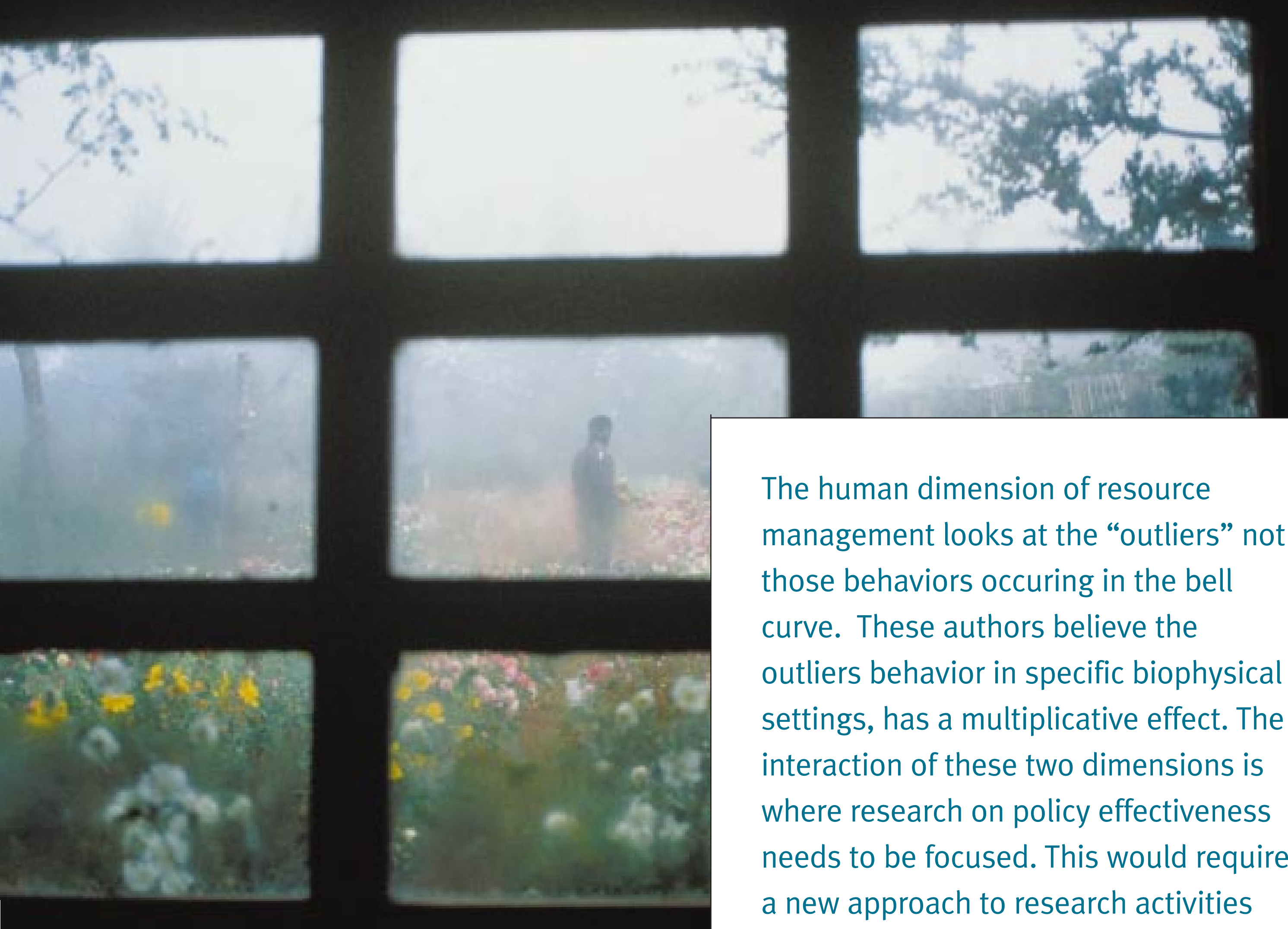


The human dimension of resource management looks at the “outliers” not those behaviors occuring in the bell curve. These authors believe the outliers behavior in specific biophysical settings, has a multiplicative effect. The interaction of these two dimensions is where research on policy effectiveness needs to be focused. This would require a new approach to research activities resulting in enhancement to current approaches to measuring conservation programs, structural changes to research activities, and changes in policy instruments.

the human dimension of resource management programs

By Pete J. Nowak and Perry E. Cabot

Since the beginning of federal soil conservation policy, discussions on how to measure the effectiveness of resource management policies have been dominated by two principal themes. The first centers on policy tools embedded within resource management programs, such as studies that compare the efficacy of voluntary and regulatory approaches in soil conservation policy (Napier and Johnson, 1998; Napier, 1990, 2000). This theme attempts to answer the basic question of how to achieve an optimal combination of incentives and disincentives for encouraging landowners to adopt resource management practices.

The second principal theme surrounds the biophysical models and assessment techniques used in evaluating the status of the natural resource base (Lovejoy, 1997; Goebel and George, 1998; Fitzhugh and Mackay, 2001). This theme addresses questions regarding the adequacy of these models and techniques to provide valid indicators as to whether resource management policies are meeting their stated objectives.

The measurement of resource management program effectiveness has typically been viewed as the interplay between the two aforementioned themes. We suggest that this traditional logical loop between these two principal themes excludes the *human dimension* of resource management.

This dimension represents a third critical—yet neglected—theme that warrants expanded research from the resource management community due to its importance in determining both effectiveness and efficiency in resource management programs. At the heart of this human dimension theme should be responses to this question: Are resource management policies inducing the right behavioral changes among the right target audience, in the right place, at the right time?[1]

Drawbacks of integrating the human dimension

Over simplification

The downfall of studying the human dimension of resource management has not been the concept, but the two major assumptions are often made about this approach. First, the human dimension approach is all too often simplified to pure economics, or to a point that excludes its complexities. This simplification conflicts with actual land user behavior.

It is assumed that the land user exhibits *economic rationality* when evaluating the trade-offs between resource management practices. This assumption is commonly reflected in policies by the expectation that land users will adopt resource management practices if there is ample financial incentive. The evidence supporting this assumption of economic rationality is weak. Instead, individuals often make idiosyncratic choices that are influenced by perceptions, beliefs, emotions and other subtle psychological factors (Gigerenzer and Selten, 2002; Kahneman and Tversky, 2000).

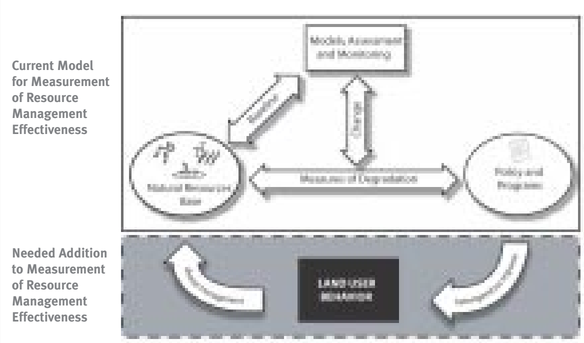
The question of participation in resource management programs has received extensive attention (Lockertz, 1990; Claassen et al., 2001). The history of these results indicates that there is no strong set of predictors of participation, despite numerous analyses that have examined various combinations of indicators. Participation in resource management programs, and the accompanying set of land user behaviors associated with the willingness or refusal to participate, is actually a highly variable situation as represented in the lower portion of Figure 1.

No consistent land user management style

The second major assumption that has negated the successful application of the human dimension to evaluating resource management programs, is assuming a *uniform management style* among land users. It is frequently assumed, for instance, that resource management plans and remedial practices will be adopted, implemented, and maintained in a manner that is consistent with the recommendations of the technical guidelines. Or, if a certain crop is grown in a certain soils-climate setting, then the land user will use the agronomic practices recommended for that setting. This assumption is similar to assuming that because a road has a posted speed limit, all drivers will adhere to this standard in a uniform fashion.

This widespread and often implicit assumption about the conformity of the human dimension to recommended behaviors, however, is not supported by the extensive analyses in this area (GAO, 2003; CRS, 1998). Studies on farming style undermine

Figure 1
Current versus needed perspectives on resource management effectiveness.



the assumption of homogeneous behavior (van der Ploeg, 1994, 2003; Vanclay and Lawrence, 1994). Other studies examining how farmers adapt or change practices year-to-year based on labor, tenure, market, weather and technological changes also contradict this assumption (Coughenour and Chamala, 2000).

Finally, there are many anecdotal observations by practicing conservationists who have noted significant differences among land users who supposedly engage in the same practice. Managers designing comprehensive nutrient management plans (CNMPs) or environmental management systems, struggle with how to account for variation among land users who respond differently to the same set of technical recommendations (USDA-NRCS, 2003). This variability underscores the fact that the relationship between land managers and their land remains highly subjective, contextualized, and not immediately obvious to outside observers. This relationship is also dynamic, based upon biophysical variations in soils, climate, and hydrology, as well as exogenous variability in tenure patterns, technological advances, farm programs, and commodity markets.

This fluctuating and arguably unpredictable human dimension of policy has been an interesting theoretical concern for agricultural economists and rural sociologists, but has largely been avoided in past research on measuring the effectiveness of resource management programs. In fact, the impact of the assumptions of economic rationality and uniform management style has been to eliminate any meaningful analysis of the human dimension of resource management and its impact on the effectiveness of resource management programs. The rationale for simplifying assumptions is understandable—without them, the potential exists for resource management policy development to become unbearably nuanced and time-consuming. Oversimplification, however, may sacrifice effectiveness for efficiency.

Advantages of studying the human dimension

Addresses both effectiveness and efficiency of a program

The effectiveness of a policy refers to the extent the objectives or goals of the policy are realized. Efficiency refers to the costs per unit gain toward the policy objectives. A policy can be effective but inefficient, much the same as it can be efficient but ineffective. Recent scientific advances have made it possible for more focused research on the human dimension so that policies do not necessarily have to compromise effectiveness for the sake of efficiency.

Being able to predict who will participate in resource management programs, and subsequently adhere to the recommendations for management practices is not, by itself, sufficient for enhancing the effectiveness of resource management programs. Simply put, if effectiveness and efficiency are paramount to resource management policy—and the current fiscal climate suggests that this is so—then knowing who adopts resource management practices is not as important as knowing where and when adoption or non-adoption occurs. The argument made here is that this "where and when" defines the missing, yet critical aspect of the human dimension of resource management programs, and as such, should be a priority for future research.

The importance of outliers and disproportionate impacts

Contemporary resource management programs will be more effective if the resolution of policy instruments is congruent with the resolution of natural resource problems. One way of achieving this goal is through research on the *outliers* that produce disproportionate impacts on environmental quality. These outliers are epitomized by the familiar "tail" of the log-normal probability distribution function curve, or simply $f(x)$, shown in Figures 2a and 2b.

So what do these outliers mean in terms of resource management? To begin with, it should be recognized that assessment techniques for identifying biophysical vulnerability are valuable, but they should not be interpreted in a vacuum devoid of land user management decisions. Consistent with the properties of probability, outliers in human dimension can have the multiplicative effect of reducing or exacerbating overall vulnerability. For example, a fragile biophysical setting may be managed exceptionally by the land user, to the point that external intervention is an unnecessary and inefficient use of fiscal resources. For that matter, management behaviors that may be remarkably bad in the larger resource management arena, for instance, may not need programmatic intervention in a well-buffered biophysical setting.

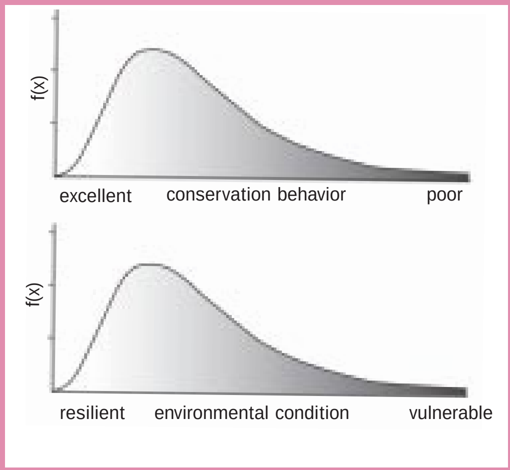
On the other hand, unbeknownst to the land user, an average or typical management decision in a very fragile setting could be the source of significant degradation. In short, rather than diametrically targeting all vulnerable biophysical settings and independently targeting all inappropriate management behavior, the focus of resource management should be upon the *interaction* of the biophysical and human dimensions.

To optimize on maximum effectiveness and efficiency, resource management research should quantitatively focus on the multiplicative effects of the probability distribution functions for biophysical conditions and resource management behavior, as illustrated in Figure 3. The traditional approach is to lower the probability of resource degradation by uniformly adjusting the conditions and behaviors that possess a higher level of risk than "average." This presumes that equal decreases in the risk of all conditions and behavior will incrementally lower the risk of degradation within the overall natural resource system.

This approach is not reconciled with the reality of the pattern of probability exhibited by these same systems, which are characterized by outliers carrying a disproportionate share of the risk. The simple fact of the matter is that we know little or nothing about the characteristics of the land users who represent the outliers in different biophysical settings, and for different forms of degradation. Instead of understanding the nature of this variance, we are blessed with an abundance of analyses that characterize the average. We feel that a research paradigm initiated to understand these strongly influential outliers in real terms would be beneficial from both a scientific as well as a policy standpoint.

Figure 2 Probability distribution function curves of biophysical vulnerability and resource management behavior.

Figure 2a depicts a general probability distribution function curve for the relative vulnerability of units of land or water to human disturbances. The U.S. Department of Agriculture National Resources Inventory (NRI) is an example of this pattern. The NRI documents how small proportions of the total land area contribute disproportionately to overall erosion (H.J. Heinz Center, 2003). A few portions of the landscape are very well buffered against degradation, while the majority needs some form of minimal protection or resource management if they are to remain productive, and the remaining proportion is highly vulnerable to land user disturbances.



The same probability distribution also applies to the human dimension of resource management behavior, illustrated in Figure 2b. Looking at a cross section of all land users, we find a few extremely "good managers" and "poor managers", with the majority falling between these two extremes. Prior research on land users in Wisconsin, for instance, illustrates how the potential for environmental degradation can be influenced by a small group of land users (Nowak et al., 1998; Shepard, 2000). That is, those in the "tail" of the distribution have a much greater probability of having an undue influence on environmental degradation. More research is needed to better understand the rationale for decision-making by these outlier cases, but we can conclude that their share of the potential environmental impact is disproportionately large enough to preclude assuming that they behave identically to an aggregated population of most land users.

What it means for research and policy in the future

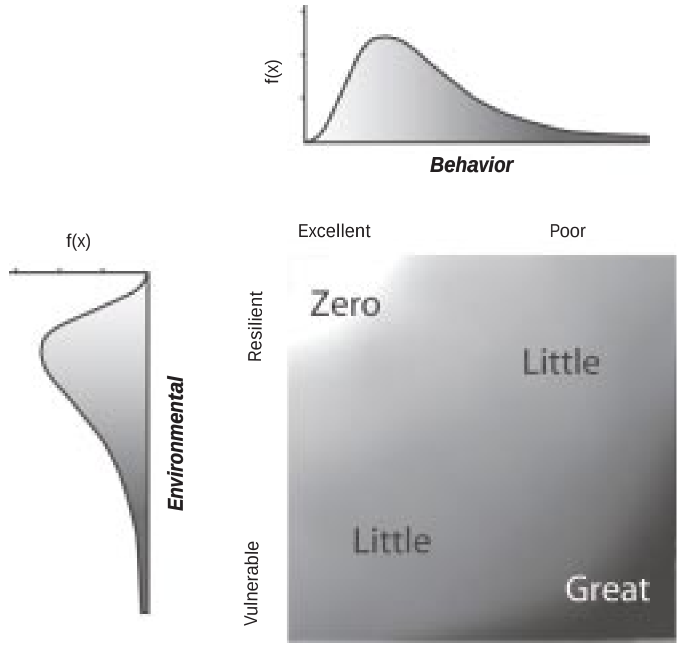
Enhance current approaches to measuring conservation programs

How do we integrate the human dimension into research on policy effectiveness in a way that acknowledges that we live in "a log-normal world" (Limpert et al., 2001)? An example of a potential approach is illustrated in Figure 4 where manure management behavior is being measured in a specific biophysical setting to assess water quality impacts. Using modern technologies (global positioning systems and calibrated load cells[2]) and analytical techniques (geographic information systems and digitized landscape data) in conjunction with a cooperative land user, allows one to investigate a challenging research issue such as this while capturing the richness and diversity of behavioral patterns in space and time.

However, measuring all human behaviors at the resolution illustrated in Figure 4 would be impractical, too costly, and raise a number of confidentiality concerns. Thus, while science and technology makes such a research approach possible, it has not been feasible in many situations as we have lacked a methodological framework to guide where we can apply these emerging techniques. This framework needs to be based on exploring the multiplicative effects of the interaction between the biophysical and human dimensions of resource management with emphasis given to the outliers.

The framework for new research on the multiplicative effects between the biophysical and human dimensions of resource man-

Figure 3
Interaction of biophysical vulnerability and resource management behavior.



Traditional resource management assessment and policy.

The traditional approach to assessing resource management program effectiveness is represented in the upper portion of Figure 1. Baseline assessments of natural resources are made, after which periodic changes in the degradation or improvement of natural resource media are modeled or measured. For example, changes in nutrient loads from a basin may be used to guide the development and implementation of policies for managing nutrients, soil loss, and water quality in the contributing area.

The rationale for this interactive process between assessments and policy is that programs can be designed and implemented for the purpose of mitigating or preventing the targeted forms of resource degradation. On-going assessments, such as monitoring or modeling activities, are employed at different spatial scales and time periods to determine if degradation worsens or abates over time. Any improvements in the resource base during this evaluation process are therefore inferred to have resulted from the resource management programs that were in place during this process. A lack of improvement, or even further degradation, is viewed as an indicator that the programs were ineffective. At this point, the policies and/or programs are either revised or rejected in favor of a different type of program tool.

This traditional approach to evaluating resource management programs relies heavily on correlations that infer a logical relationship between assessments of biophysical conditions and policies intended to affect those conditions. Such inference is akin to the "lumped-parameter" approach used in modeling methodology. This approach "lumps" the spatial variability within the geographic unit together and subsumes it by aggregating its properties to a single parameter assigned to a coarser scale. In the case of natural resource evaluations or water quality programs, the final scale used to inform policy is often orders of magnitude larger than the scale at which land user management decisions occur (Fletcher and Phipps, 1991; NRC, 1993:134). Therefore, the inferences drawn between policies and their effects have their basis in what we term *compounded aggregation*.

In general, compounded aggregation occurs when a single coarse-scale variable is compounded from the aggregate effects of variables representing phenomena at multiple finer-scales. A significant problem can emerge when using inferential logic based on compounded aggregation of human behavioral patterns. Such inferences and the supporting statistical reasoning can be invalidated by a high probability committing an *ecological fallacy* (Robinson, 1950). This fallacy refers to an incorrect inference whereby one assumes that the individual units of a group behave identical to the larger group itself (i.e., generalizing the characteristics of an aggregate to an individual component of that aggregate). We posit that the prevailing logic underlying the assessment-policy feedback loop exhibits this fallacy, and thusly ignores the salient human dimension that really determines the outcome of this iterative procedure.

agement needs to be guided by the scientific concepts of *sampling* and *scaling*. Sampling and scaling are the methodological concepts that have the potential to integrate the human dimension with the biophysical setting needed to understand the processes occurring in the lower-right portion of Figure 3.

An example of noteworthy research is how off-site migration of phosphorus (P) has been shown to occur more readily from zones where frequent runoff generation due to variable source area hydrology spatially coincides with areas where historic management behaviors have elevated P levels in the soil (Gburek and Sharpley, 1998; Walter et al., 2000).

Another example where these concepts have already been applied was the integration of soil test results, hydrologic data, and measures of animal density to spatially target phosphorus management planning for Pennsylvania (Kogelmann et al., 2004). Unfortunately, this type of imaginative use of data representing different scales and sampling frames has been slow to develop in the social science research that would logically parallel these studies and examine issues associated with the effectiveness of resource management policies.

The norm for social science research in the resource management arena has been to use some form of random or representative sampling to measure the range of prominent behaviors in the study area. Yet, research is needed to explore the proposition that random or representative sampling may not be appropriate when assessing the effectiveness—the extent the policy is realized—for resource management programs. If we wish to enhance policy effectiveness, and if only a small proportion of all social-biophysical interactions are causing a disproportionate amount of degradation, then why should we use a sampling frame designed to elucidate the average of all behavior? Instead, some form of a stratified sampling frame is needed where the emphasis is on vulnerable biophysical sites where inappropriate human behaviors would have the greatest probable impact on resource management efforts (e.g., lower right portion of Figure 3).

Ranking the vulnerability or fragility of biophysical settings is a rather straight-forward exercise due to the wealth of data and computing technology available for such calculations. The same cannot be said of behavioral measures that have implications for natural resource management. Thus, this situation will require an inventive merging of qualitative and quantitative techniques to identify this prominent portion of the behavioral distribution. For instance, local conservation officials and staff are often aware of who does not participate in programs. This local indigenous knowledge coupled with assessments of biophysical vulnerability could be used to direct social science research (i.e., to the "where and when") on impediments to program participation.

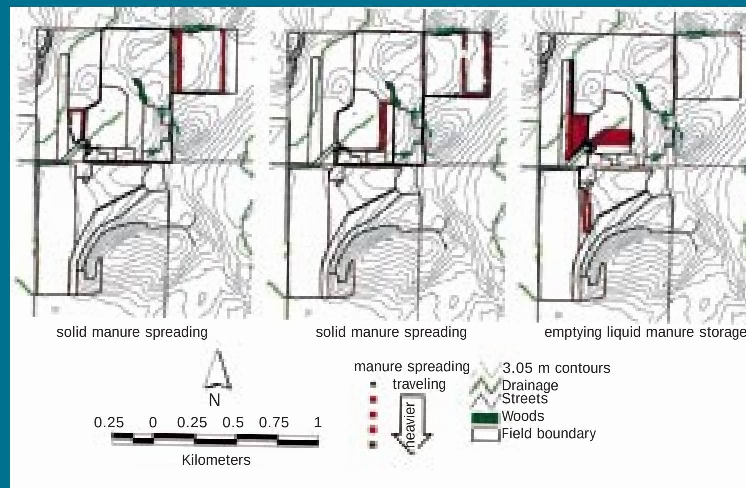
Our call for research on developing different forms of social science sampling frames in the area of resource management is not new (Nowak and Korsching, 1998:175-177). The human dimension of resource management or the "where and when" of behavior in regards to specific biophysical settings, is what may determine the impacts within an environmental system—that is to say, a "where and when" approach is biased toward multiplicative situations. These few multiplicative situations may have more to do with the effectiveness of any policy than the typical measures of central tendency used in most research today.

The second concept that needs more attention in future research is the fundamental principles of spatial analysis such as those used in geographical information systems (GIS). Recent advances in ecological sciences have already investigated the issue of scale across broad landscapes, and these ongoing scientific endeavors hold a number of opportunities for designing and implementing resource management policy (Allen and Hoekstra, 1992; Levin, 1992; Pascual and Levin, 1999; Turner and Gardner, 1990).

Environmental degradation does not occur at a particular scale (e.g., sub-field, field, farm, watershed), but occurs across scales, and often in a nonlinear fashion. Future research on the human dimension of resource management needs to address this basic fact. For example, conducting an assessment of practices used by farm units may "average out" and therefore miss small portions of the farm where the practice is inappropriate in a vulnerable setting. Implicitly focusing on one scale such as studies where farms or a watershed are the unit of analysis—a common approach in current research literature—may miss important interactions occurring at finer or coarser scales.

Social science research requires more than a simple cataloging of what is being done; one must also specify where and when it is being accomplished in order to account for the biophysical settings of those behaviors. This will require attention to scale. Measuring both behaviors and the biophysical setting of those behaviors using spatial analytic techniques also have the added advantage of enhancing research across disciplinary boundaries.

FIGURE 4
RATE, LOCATION, AND TIMING OF MANURE PLACEMENT ON A WORKING FARM



Structural changes to research

Since the early 1980s we have witnessed the transition in the objectives of resource management policies from a narrow focus on protecting soil productivity through reducing soil erosion to broader and more complex environmental amenities (Cox, 2002). Carbon sequestration, global warming, biodiversity and species protection are only some of the complex issues that are discussed in the context of today's resource management policies.

The complexity in the objectives of today's resource management policy will require at least two structural changes in how we conduct research on these issues. First, if policy effectiveness is determined by the outcome of the interaction of behaviors with a biophysical setting, then interdisciplinarity will be a requisite for future research initiatives. Investigating the interactions discussed here will require the skills of both biophysical and social scientists working in a true interdisciplinary fashion (Kinzig, 2001). Second, organizations and agencies charged with implementing resource management policies will need to examine how staff are rewarded or penalized in this process. If staff are rewarded on the basis of the relative quantity or gross amount of practices deployed (e.g., number of contracts, gross land area protected, plans written), then these incentive strategies need to be redesigned. Instead, even if the amount of plans written or fields "protected" is small relative to the total, the agents charged with resource management should be rewarded for addressing outliers (inappropriate behaviors in vulnerable settings) because the relative impact may be proportionately greater. It is the relative quality (i.e., the "where and when") and not the aggregate amount of the resource base protected that will determine both the effectiveness and efficiency of resource management programs. In essence, we need to provide greater rewards for working in the lower right of Figure 3 even if it is a more difficult and challenging process (Nowak, 2003).

Policy needs to acknowledge the switch

Designing resource management programs solely around biophysical vulnerability implies that the resolution of the policy instrument will not generally be congruent with the resolution of the problem since it ignores interactions with the management decisions of the land user. Current and past attempts to "target" resource management programs have selected broad landscapes based on biophysical characteristics, or hydrologic units based on water quality parameters. The human dimension in all these cases has been characterized by erroneous assumptions of homogeneity used to sell or promote the resource management program within these geographical boundaries. These voluntary efforts are designed to appeal to current cooperators resulting in an implementation effort based on the lowest common denominator (i.e., the mode of Figure 2a). Policies have ignored the fact that it is the outliers, biophysical and social, who tend to determine the effectiveness of any resource management program.

We have argued that research on the human dimension of conservation is now needed if complex resource management programs are to be enhanced in terms of program effectiveness and efficiency. Yet, this is not the typical call for more research in already established directions. This research initiative has to be grounded in the recognition that there is as much diversity in the human dimension of resource management as there is in the biophysical resources they manage. Moreover, the meaning or interpretation placed on those behavioral patterns needs to be framed by the biophysical settings where they occur; identical behaviors are not necessarily equivalent as it depends on where and when they occur. Social scientists and interdisciplinary collaborators will need to be able to develop innovative methodological approaches to begin to comprehend how outliers, disproportionality, sampling and scaling influences our attempts to design and implement a more effective and efficient resource management policy. We encourage others to join with us in addressing these emerging challenges.

Endnotes

An earlier version of this paper was presented at two symposia events held at the 2003 annual conferences of the Soil Water Conservation Society, in Spokane, Washington, and at the Soil Science Society of America in Denver, Colorado, November 3, 2003. Together these two symposia, that addressed the effectiveness of conservation practices, mark the fourth annual joint symposium organized by the two societies and presented at both societies annual meetings.

[1]This question paraphrases a definition of precision agriculture by Pierce et al. (1994).

[2]Load cell system developed by Digman et al. (2003) based on U.S. Patent #6,024,305 and U.S. Patent #6,206,306 granted to Claude McFarlane of Knight Manufacturing.

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