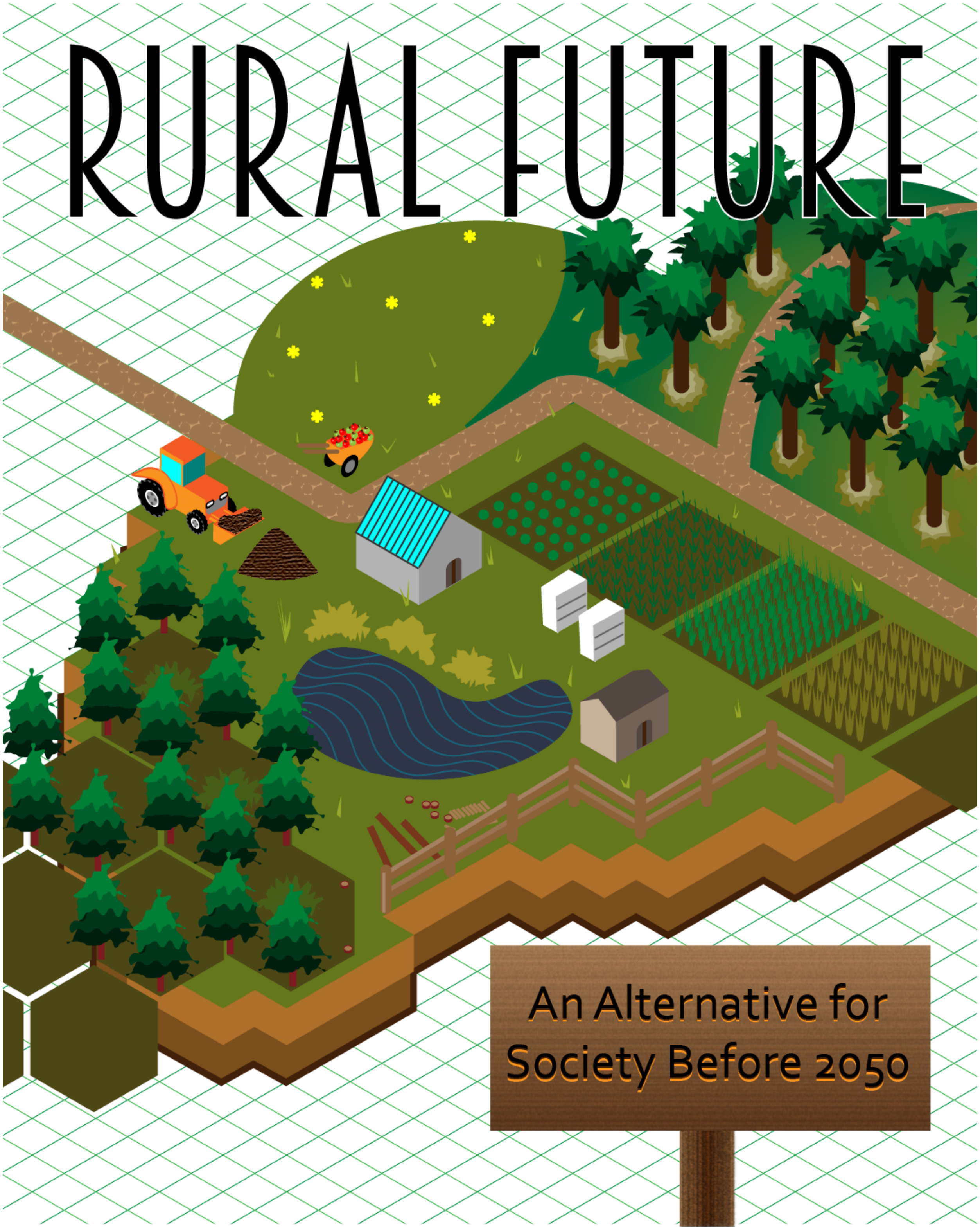
RURAL FUTURE
An Alternative for
Society Before 2050

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By: Robert H. Giles, Jr., Ph.D.

Edited by: Laurel Sindewald

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Rural System's Time

Rural System and its Rural Knowledge Base Group will respond to demands of the rural decision-maker for many different response periods or over temporal-need horizons. The demands of landowners will relate to costs, perceived importance, gains, and expansive uses. Our possible time-related crops and biomass (energy) products include crop residue after harvest that must be gathered, processed, and compressed in order to increase efficient handling, and reduce time for transportation and storage for use.

We are locked into planning timing for:

- Inventories of data, maps, and text pages;
- 24-hour responses to select optimization;
- Annual reports and updates;
- 5-year annual analyses of objectives and projections;
- Recurring projections to the 150-year standard horizon;
- Limited analyses for a comparative present date, 0 to 5 years, plus 50 and 100 years; and
- Generalized forecasts and feedforward.

A changing graph with computerized links will be commonplace and will put each area under Rural System management in both a historical as well as a futuristic context. The oldest trees are physical manifestations of events when the seed sprouted, and a collection of survival response to unnamed events during the years of the tree's life. The oldest trees may be related, then, to the Jamestown Settlement, the Declaration of Independence, the surrender at the Appomattox, the 1930s Depression, and World War II. These events—the oldest trees—the present, and a planning horizon of 150 years can all be seen and related, at least linearly on a time line *(graph),* when presented. The relative significance or proportion of the future planning period to past events may be noted and comments developed in a separate, secure file.

Rural System's time is needed because relative time thought, even human time-value, is not constant or standard (e.g., hours before execution, before marriage, after exiting an art gallery, after a harmful accident, certain drugged states, after a desired election outcome, or the final dedication of a wilderness). The longer the planning period, the greater will be the effects of "present-discounting" estimates used[1] on the hypothetical or likely expenditures, with fixed-rate over time.

Within Rural System, staff may revert to "ecological time," but we may continually develop a useful concept of time as a condition—a named period not unlike "an hour," "a minute," "a year," or perhaps a calendar modifier (or only a coefficient). We work on the sense of relevant change, and the idea of both long-term production and the ponderous rate of nature in achieving certain desired conditions for people. There is no intent to suggest or imply that the future will be like the past. Many people believe that events and rates, particularly of recent technological change, have increased, and thus the timeline for the future should be decreased in length exponentially.

We also plan to continue to work toward comprehending and using knowledge within Rural System. For example, we know of and seek to comprehend the movement of Earth plates, the once-southern plates, equatorial—those of the Carboniferous period of the geologists, about

[1] Conlin WM. 1973. Feedback functions in MAST. M.S. Thesis [Unpublished]. Blacksburg (VA): Va. Poly. Inst. and State Univ.

300,000-400,000 years ago—after the experiences of the different periods, from the Carboniferous to the Cretaceous with its now visible sea-shell prints in the weather-resistant mountain crests' up-thrust stone layers. We see the evidence of where dense organic growth extracted nutrients, dried and formed dense organic layers, and were then covered by vast mountain erosion and volcanic effluent, forming today's gas and coal seams. Difficult enough to comprehend the ancient realm of fossil plants, that time-since thought must be overlain with awareness and comprehension of Earth plate tectonics – "floating around" …edges submerging others… slowly, another "time," back in the millions of years lost and found in the calculations of Earth-age.

There are named, temporal rhythms (timed changes) observed in nature, such as the high frequency ones of the human brain, heart-beat, and respiration, and there are about eight such named-rhythms experienced in life forms. "Circadian rhythm," is observed, re-occurring change in life-forms (at about 28 hours), and exists in the absence of rhythmic environmental change, e.g., daylight.

Within Rural System, time consciousness is critical to staff in understanding the dynamic status of an individual organism (or subsystem being managed). That animals vary widely in response to the same stimulus (e.g., to a capture-dart drug) should come as no surprise if the response occurs at a different time of day. In a community, when an animal is different, the community is different. There is probably a survival component within the diversity.

As an example, the all-pervasive output of the adrenal gland, corticosterone, varies from 0.4 of the mean when sampled at 4 p.m., and 1.8 times the mean when sampled at 4 a.m. (in darkness). This change of 4.5 times can influence an animal's response to predation, pesticides, sudden temperature changes, and probably conception. Noise can increase estrus, decrease male fertilization, and reduce pregnancies and fetuses. The significance is that an animal on one day is not a "point observation" to the informed ecologist, land-use manager, or modern natural resource specialist.

Each land unit is probably unique, at least at a point of time. A planning period of 150 years (also called the planning horizon) is used within Rural System. In Rural System, the period is always estimated as from the current date. It is always shifting ahead one year to look ahead for 150 years (a sliding-mean software unit).

We attempt diligently to comprehend and use the rhythms found in nature, some newly found, some lunar-related, and others, when known, may provide controls—computer-aided and site-specific—over the essential processes for humans within the post-2050 AD Earth-Village System.

Chapter Six

Design and Rationally Robust Work

The thought processes and proposed policies and principles behind the Rural System design are expanded, made more practical, by the emphasis of ***rationally robust work***.

By now, you must be wondering about what the new procedures are that will be used to run Rural System, and to show good results. In previous chapters, I've variously listed methods and approaches to creating Rural System. What, more precisely, are some of the basic differences ahead? If so much of what has been proposed is not very new, just a new way of arranging things into a system, then what can be expected? Within Rural System, we have knowledge about where there *is* knowledge, and we know special ways about how to use it. We have incentives for using it, making reasonable "joins," both to make money and to reduce losses. We have an almost anti-science attitude about getting and using knowledge. We've studied history, and we know that the future will not be like it, because of rationally robust work.

I was taught and have participated in science in the Sputnik era, during which science was viewed with national pride and pursued with nearly religious zeal. I've debated "basic" and "applied" as if there was more at stake than a budgetary criterion of the National Science Foundation. With colleagues, I have been involved with the "scientific method" and wrestled with the interplay of *deduction* and *induction* (Chapter 5). I've created models, done curve fitting, and advised people on a wide variety of quantitative questions, some of which could be aided by statistical analysis. This experience has suggested the need for an alternative to the science paradigm. An alternative *must* exist for the rural system… it's *rationally robust work*.

There is nothing tight and crisp that I can call our work, like a paradigm or theory. Rationally robust work has a set of characteristics, many interlocked, that together are significantly different than some approaches and techniques used elsewhere. The work starts with the imperative of recognizing "a situation" and moves to achieve a "satisfactory condition." Rejecting the status quo, projects move toward results of optimization, having demanded precise objectives. Fuzzy objectives may lead to using consequence tables, the important consequences being rephrased objectives. Consequences are to be (often) estimated from computer models built for GIS maps. They use often-rejected concepts of risk taking, relaxed confidence and precision, greater use of *ranges* and *medians* than the *average* statistic, and the knowledge of equifinality existing within natural and social systems.

A dynamic knowledge base is created, managed, and maintained within VNodal, primarily for improving models leading to optimization. The knowledge then used is within decisions for a system to achieve a set of objectives for the 150-year future, all at very low expected costs. In a challenging reversal, operating a system for "making money" is seen as the cost of achieving those objectives. The following may help clarify the characteristics of rationally robust work leading to a satisfactory condition.

Anti-Science?

There is need for a strong, sustained effort for gaining and retaining and then using knowledge, parameters, distributions, rules, and procedures, known with high confidence. We have outlined the epistemological bases (Chapter 5), and we know that induction and deduction are the cornerstones of science. These two ways of knowing have served people well, but they are inadequate and overly simplistic for progress in Rural System and related fields. There is need for rationally robust work, a concept of decision-making and action-taking that is timely, tentative, and, in a low-risk, high-influence domain, always accompanied by feedback and timely response to the perceived future. It seems irrational to insist that rural system work (and probably many other related fields of work) exclusively follow the scientific method.

Research, like the good doctor, has an aura about it of objectivity, formality, and rigor, but it is not an aura needed in all fields. Research has solved some problems, given us some advances, and has given many people a useful pattern of thought for over a century. Increasingly, that pattern is shown to be wanting. Research is said to answer questions, but it is also said that "if you ask the wrong questions you will get wrong answers." Research is said to be descriptive, but of what?

There are many, many problems faced for which research has neither the answer nor an approach. Science can produce deceptive images, images where matter does not exist. Induction, while good, is not sufficient. It has little to provide in knowing the unique or rare event. It is of little service in highly variable situations with few observations. It is infeasible in many situations (e.g., hypothesis: rabies virus inoculation is not always fatal). A substitute is needed, at least an alternative.

The needs are conspicuous in rural resource management—and throughout the world. We may yearn for research, for the specificity and confidence it seems to give. The hard lesson, not yet learned, is that it is very expensive, takes much time, requires specialists, and after the reports of results are filed, risks remain, and there are persistent delays between discoveries, possible uses, and mature use. We have not learned that we do not work well with simple fruit flies in all cases. We work with incredibly large, complex and changing systems. Some are unique and their every sampling period or area is unique and they cannot be assumed as uniform as cloned white mice. They are about as predictable as the flight of a flock of pigeons. People with hard questions to answer are short on money, time, skills, and often alternatives. Answers are needed. Rationally robust work is badly needed for all of the realms of natural resource management... all rural areas.

It is easy to be hypercritical about anything. I center on general systems work, results urgency, and relaxed confidence demands paired with feedback.

One problem with research once came upon me like a hawk over my tree stand: research, in its traditional form, is prohibitively expensive. Suppose there are about 300 important bird species in India. There are needed about 200 observations about the characteristics or parameters for each bird to complete all entries in a wildlife information system. These 200 items are selected from a much longer list. Some factors needed for each species take years of study, others only a brief period. I round off my estimate at a very conservative estimate of one year needed for each observation, and then I suggest an even more conservative $50,000 required to pay and equip a scientist for a year. It includes all travel, rent, equipment, computers, support staff, and salaries but it has never been analyzed exclusively for wildlife research people. (Frankly, I think the amount exceeds $50,000.) While several observations will be made in a few days, I assume I can make one official entry in our database per year. That cost is very great. If there were 1,000 scientific wildlife researchers, it would only take 60 years.

We cannot meet the research needs of the birds of India alone, much less those of the world, by the conventional, accepted research pathways. We have not even mentioned the similar research needs of the mammals, reptiles, amphibians, mollusks… and, oh yes, the fish and, equally as important, the insects—whether we study insects as disease vectors, critical food supply for some other animals, or objects of specific management, such as the garden butterflies.

Once there was the notion of "do basic research" and then publish it. It was a rule within graduate schools, and the hidden assumption behind it was that "one day your findings, in a process unlike that of your own discovery, would be re-discovered and put into practical and to otherwise good use." In rural systems, with many parts threatened and changing, *one day* may never come. "Irrelevant" may be the near-perfect word for a discovery made for a species that has just become extinct.

In presumably the most logical of all areas, research, I now think I perceive an illogical underpinning. It is illogical for us to continue using the classical, experimental, inductive approach to gaining knowledge about rural resources. Wild faunal resource workers, for example, will never gain the budgets needed, the staffing and expertise, the time, or the requisite use rates of key conclusions to be reached. It is irrational for us to proceed in the current classical fashion.

I sense that the following components (with the traditional caveats about overlap and limits) create a current *situation* in which classical decision theory has no meaning and little relevance to significant rural resource decisions (and thus the future about which I write). The situation:

- There are now many more educated people in society than ever before (consulting base-date comparisons of 1949-50 and the multiple use, sustained yield, and planning legislation passed by Congress around that time).
- There are now, still, many poorly educated people in US society. Some are solipsistic, ascientific, folklorists, and metaphysical beliefs abound—even among university graduates.
- Many people believe that their every opinion (studied or not) is equally important or valid, following the peculiar nationalistic logic that if every person is equal then every opinion of such people is of equal value.
- There are few people in society with outdoor experience beyond weekend outings at a summer camp. There are masses with massive lack of knowledge about the "wilds"; ignorance is present even in those with outdoor recreation, farm, and forestry experience, and even after improvements in biology, ecology, and environmental education.
- Few people have farm experience (less than 30% of the US population is classed as "rural").
- There persists the flawed logic of the masses, i.e., that public forestry is the same as private forestry.
- Few people realize how many potential alternatives there are for every natural resource decision. The best place to put X (e.g., a pond, a recreation structure, etc.) probably has 10 elevation classes, 8 aspect classes, 4 slope classes, 4 landform classes, 2 nearness-to-stream classes, 4 nearness-to-road classes, and 4 soil/geology classes. Thus, the place must be decided from among 41,000 spots.

- There is slow increase in awareness (but an increase, nevertheless) relating to "landscape ecology" issues (i.e., generally the off-site but nearby consequences of local actions on large tracts of land and water, especially within or near urban borders).
- Few people realize that if a system has 7 components (and all natural systems have more than this) and the decision makers are 0.90 sure of each critical part, then the chances of a correct outcome are barely 0.50.
- Few people realize that *sequence* is a major part of natural resource decisions. This involves permutations … how many different ways (sequences) can things be done (like irrigating, fertilizing, and thinning). Seven components, for example, can be brought into a system or into a decision in 5,040 different sequences. The decision-maker must select from among these. Usually "the best one" is desired. The demands for even "good" (rarely "the best") decisions are exorbitant.
- Few people comprehend optimization, briefly meaning the computer-based means to select the best point or condition from among millions of options with named constraints. Optimization processes have only been computer-available since the mid-1940s. Some people demand their use; the majority is unaware of their existence, meaning, capabilities, or limits.
- Nowhere in society are planning horizons longer than they are in natural resource management and decision-making. Financial planning rarely exceeds 40 years; isotope half-life and nuclear energy waste disposal has not penetrated the national conscience. There may be evolutionary limits; the ability of humans to deal with long time-frames has not been tested well for its survival value. (Until recent time, such long horizons have not existed; human longevity was less than 40 years.)
- Because resource decisions in the public arena can be viewed as investments in the future (e.g., retaining old-growth forests, building dams, conserving soil for future farming), issues of rational investment decisions are appropriate. The profound effect of the interest rate used in investment decisions for the long-term is well-known. The proper procedure (or rate) for investment remains hotly contended. Even if interest rates and procedures could be agreed upon as policy for public investments, over the long time-periods of natural resource investment, national policies distort discount rates. Such rates, regardless of policy distortions, are conspicuously dynamic over the period of resource investments and they affect public resource prices and land values.
- There are more people with more leisure time than in the past (thus "free" or "abundant" time to dabble in public participation). Individuals within "the public," as part of public participation policies, have been asked to express opinions about topics with less time than the average legislator gives or gets to spend on a vote. There is inconsistent and always temporary public participation. There are inconsistent agents (e.g., due to lateral moves, career ladders, retirement options, relocations, etc.) to present a consistent proposal or set of premises and agreements, or sustained expert advice, to private land project investors or public land decision participants.
- Environmental impact analyses and assessments continue unabated, even with well-recognized limitations (e.g., no mandate, no social consequences assessed, trivially limited sets of alternatives, and disregard for actual or likely budgetary limits and

dynamics for the projects being evaluated). The public is unaware of the limitations of the analyses or of their non-effects, over-confident in the process.

- There is dynamic and inconsistent intra- and inter-agency policy that affects recommendations, risks, costs, and prices on private rural lands. There is changing scientific knowledge, changing technology, and thus changing efficiencies (and costs). There remain very large—but variable and unpredictable—budgets, and thus variable needs for private financial supports or agency staffing and advice. (Money, just as the sun powers ecosystems, powers all action on the land.) Delayed and unpredictable budgets (and frequently discontinued funding that prevents a project from achieving benefits for people) make every decision risky and potentially open to litigation, and failures are common. But commonly, these failures are not the fault of the agent or agency but of the budget process itself (call it an "exogenous force").
- Getting elected officials, with a 2- to 4-year electoral cycle, to deal with problems beyond their electoral horizon is an obstacle, unresolved after two centuries, to improved natural resource management.
- Notable scientific accomplishments and introductions to science have created, in the general public, an environment of excessive expectations for technology, resource manipulation, and data gathering. Science has been touted as the primary methodology for improved decision-making, but science itself is currently being openly criticized.
- The rise of globalization (e.g., T.L. Friedman's *The Lexus and the Olive Tree*,[2] and *The World is Flat*[3]) expands the scope of almost every decision, not only within the US (e.g., the impact of changes in logging in the Pacific Northwest on lumber prices and supplies in the Southeast), but the world (e.g., the tax on lumber cants sold in Japan related to North American timber harvest schedules that affect elk forage over many years). The climate issues are "global incarnate."
- With the rapid rise of committee-ism, such that no "one" decides, there are long delays in decision-making; anonymity is gained, conservatism prevails, and novel or singular ideas are dismissed (or never voiced because of the predetermined fate of such ideas). There has been a concomitant, rapid rise in litigious attitudes; many people and agencies are afraid of being sued. The direct penalties are small; the costs and delays are enormous. Youthful enthusiasm and zeal for resource management, land, and the agency, when embodied, can be jailed by punitive lawsuits, often arranged by people without standing to sue.
- There are many exogenous forces affecting every situation in which rural resource development is proposed, or projects contemplated. Trained and experienced people consider these as part of every decision. Few people in the general public now do so for some of the above-listed reasons. In decision-making on rural areas, the forces above must be combined with considerations of wildfire, storms, disease, insects, pollution (air and water), poaching, vandalism and theft… and increasing challenges from excessive drug users.

[2] Friedman TL. The Lexus and the Olive Tree. 1999. New York (NY): Farrar, Straus, Giroux.
[3] Friedman TL. The World Is Flat: A Brief History of the Twenty-first Century. 2005. New York (NY): Farrar, Straus and Giroux.

- The federal—and some state—rural resource agencies now seem to be in the grips of anarchists. The minority denies the rational democratic premise that after votes are taken, everyone tries to “go along.” The minority can prevent the views and conditions desired by the majority from being realized. This failure of the entire current democratic process is not limited to one agency—this needs to be made clear to the employees of agencies and the public. I think it is a crisis within the US sociopolitical system as a whole… affecting rural resource use decisions, among many other topics and problems.
- Collaborative efforts are now rare within public agencies. Equal, diverse forces contest and cancel-out each other. Social objectives are unclear while sub-group objectives *are* clear, thus vast sums are spent on the contests, and people (like my grandson at his first soccer game) leave the “field” asking, “who won?”

Rather than continuing to add to dimensions and developing an abstruse argument, I assert from years of experience and observation that most of the above items are true and that, even if as many as half were flawed, the conclusion would still be the same. We do have a *new situation,* and it is not subject to classical decision theory or reasoning from science. We need an alternative, and the only one on the horizon is ***rationally robust work*** toward a satisfactory condition.

The Satisfactory Condition

The rise of environmental interest, while favorable, has had negative, unavoidable consequences within the realm of management. Maybe I cannot solve all of the problems, maybe none of them, but I think that by analyzing the situation and applying some creative effort, perhaps some tentative better condition can be created.

We can reject the quaint phrase: “we learn from history that we do not learn from history.” History can be a wonderful teacher if we have the ability to hear. We also need a place of order where we can store what we hear and otherwise sense. We get too much noise. We focus on details and miss the messages. "There will be a flood!" This is near calamity, yet we concentrate on depth, flow rates, dollars lost, and other details. We need to sort out the things we now know, like that floods and fires do occur, trees grow, epidemics occur, and people need each other. People help each other. We know many acidity limits on plants, what will poison cattle, and that tomatoes will not grow well under walnut trees. We know a lot! We can gain new order.

I remember well a skeptical student, a veteran, noting the impossibility of predicting the leader that emerged from a Vietnam village and turned the tide of the war in an area. He was right, but that “leaders will emerge” can be predicted. When generalized, modeled, and retrieved in conjunction with other things we know, we will achieve our objective. Our objective is to know, not to do research. I have already discussed the means of knowing and the notion of degrees of certainty in Chapter 5. One part of that potentially-growing knowledge base needs to be from tribal leaders, villagers, and practical folks that have made daily outdoor observations as they have regularly tended cattle, poultry, bees, and their crops.

We have been held for years by the wisdom of the technical literature analyzing decisions. It varies, but it usually has the elements of general systems theory sketched in Chapter 2. Typically, there are objectives, facts and figures gathered, and they are processed in several ways (from very simple to complex computer means). In some instant (the tap of the gavel or a registered letter being placed in the mail slot), the decision is made. There may be feedback that improves the decision when it is next made. Major decisions are singular, almost by definition. I now believe, however, that classic decision theory is inappropriate for public rural-related natural resource decisions. While there are similarities between classic decisions and the events within the public so-called "decision arena," I now believe the differences are so great that an alternative analysis is needed.

The Status Quo

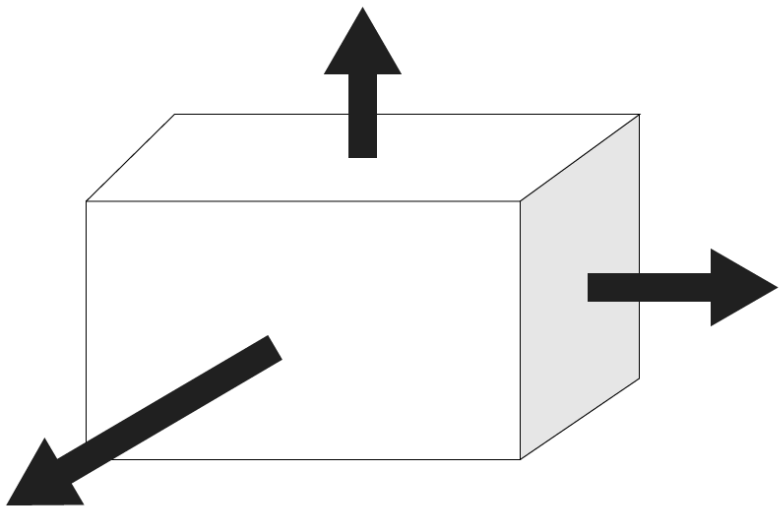
There is another option, of course. That option is not to change—to retain the status quo. This may be necessary if there are no means seen for change, no resources, no creative option. The status quo may be pleasing to some people. A generally bad situation may prevent an agency or individual from doing a particular “good” that is offensive to some group or individual. Some people have been said to “stir the pot” as a strategy to prevent action. Preventing action may be the intent—it can lead to analyses that can lead to major agency changes or their abolition … not intended.

It is difficult in some societies to admit that there are no solutions to a problem or situation and no hope for one emerging. Things may be perceived to be as good as they will ever get. Perhaps that is the case with large, complex problems, with long histories and strongly-felt needs, but conflicting objectives. The natural resource domain seems to have its own breeding ground for problems. Herein, the underlying assumptions are that within rural systems (and within the Rural System corporation being proposed) there is just such a problem, and that there is no singular solution. That condition—the status quo—however, is not acceptable, and thus another condition will be sought. It is unlikely that it will be judged to be good, only better than the former condition. It will be well-prepared for the next changes likely to come, as we discuss the potential crisis years of 2030 AD and 2050 AD.

We must return to epistemology (Chapter 5) and its question of how we know… including how we know whether we have a problem, a solution, or can fix it with the resources and ideas available within the time remaining. I suggest that we back away from the profound bias of “scientist” and start with person *qua* person, then advance to the knowledgeable person, living within a state of tentative certainty, grounded simultaneously on several epistemological bases, most importantly using heuristic convergence. The following are the parts, the major dimensions of rationally robust work for us all, together, on which we may work. Together, the parts become an effective, new, whole way to achieve the desired satisfactory condition.

The Procedure

People live in a perceptual, mathematical space. Here, it is shown as a 3-dimensional box but it needs to be imagined as a complex volume, much like a many-facet jewel, tumbling along. The arrows suggest that appropriate conditions have been exceeded and are outside of the box.



People want to stay within the box. This is what they know, where things are safe, where they know what their parents and their history and culture have taught. This is where their survival skills work. In some cases, the limits are laws. It is illegal to go outside of the box.

A simple box has three dimensions, and for people these might be food, housing, and clothing. Outside the box might be inadequate food or poisoned or polluted food. A little pollution may not be too bad, but if it exceeds a threshold, then sickness or even death might result. A reasonable person or group wants to avoid the thresholds, the limits. The closer to the center of the box, the better.

The sides of the box are not very precise. Many variables, including the variation in the health and abilities of the people within the group, influence the limits of the box. If a limit is threatened (e.g., effects of a toxicant), but no one knows the exact limit, then it is reasonable to make decisions to avoid coming close to such limits. The limits are fuzzy; the center is safe; avoiding the limits is conservative.

It is easy to understand and appreciate administrative, budgetary, and legalistic reasons why there needs to be taxonomic difference between basic and applied research. Only recently has it become evident how harmful that classification has been to science and to applications of research findings to rural problems.

Science is. It exists, multidimensional but continuous. There is no longer any meaningful difference between basic and applied research taxa; they are artificial and invalid under the rules of nomenclature and should be abolished as intellectually, personally, and organizationally divisive. They are the roots of great ineffectiveness in the scientific community -- especially those dealing with land use questions. In the future, we can stress wholeness, similarity, and generality. Then predictions will be more correctly made.

As an example of the rationally robust work, let scientists not engage in the debate over whether studies of the endocrinology of mid-line color changes in certain stream fish are basic. Such studies are the substance for interpreting the effects on fish of non-point water pollution from farming and forestry practices. When pollution disrupts the endocrine system, and prevents color change, there is impact. When color change is a basic sequel in a courtship ritual, then its failure to change causes reproductive failure and changes in expected population abundance. The real land use and impact question is not whether pollution killed fish, but whether it resulted in a generation not appearing alive. From research, such a question can be answered, understood, and corrective changes made. There is only one science. It needs to be cast as rationally robust work.

N-Dimensions

If two topics, such as water and temperature, were discussed as they might relate to tree growth, then we could say that we are discussing a two-dimensional system. We could display it on a 2-dimensional piece of paper, a graph. If we discussed three factors (water, temperature, and light), we might imagine trees responding and being displayed within a box, a 3-dimensional space. Responses change in time (so we add the fourth dimension) and results differ depending on the region of the people being discussed. The area may change due to shifts in ownership, flooding, and wildfires. It is a changing, n-dimensional or many-dimensional entity. Difficult to imagine, the situation can be pictured in an elementary way as an ever-changing, moving cloud or blob. Thinking about a three-dimensional thing is easy; four-dimensional thought is difficult (except for a 3-D object tumbling through time, the fourth dimension); n-dimensional thought seems available to a limited few people. The natural resource situation typically requires n-dimensional thought, or aids to approximating it, with expectation or probability thrown into most of the dimensions.

The weakness in the footings of the present procedures has been presented above in order to begin to understand why an alternative means is needed to arrive at a satisfactory condition within rural systems and within many public natural resource agencies. Understanding the situation or "condition" seems necessary. An alternative is to ignore the present situation and creatively develop a perfect one, then to compare the present to that one and make changes. That's a dream, for it ignores the power that moves within and outside of agencies, as well as the strongly-held value-system forces at work in rural lands and the urban fringe, and then assumes there will be action as if history has no meaning. The problem: decisions must be made about system objectives… and by these, if achieved, people recognize "the solution."

Naive people like to look for solutions, even "the" solution, but in very complex situations with long planning horizons, there is no singular solution. Even if one could be found, it will be judged inadequate the next day because conditions have changed (perhaps personnel, even objectives). Rather than a solution, we are looking for a condition, a satisfactory condition. It will not be right, or perfect, or even optimum. It will be satisfactory if we work hard, acquire knowledge and build a knowledge base, use available knowledge, and create systems that utilize well things that we now know about the way that complex systems tend to work. Specifically, we work toward achieving Rural System's objectives. A new condition can be created. I call it rationally robust work and I describe it below and hope to work with you and others on seeing it clearly and implementing it.

Decision-Making at Fine Spatial Resolution

We once created, in Virginia, a database of about 50 factors in each of 1.1 million, 27-square-acre map cells. (It had no backup system and was destroyed by a political storm. But, much of it has been restored with more factors and greater precision.) Such a database allowed, for example, computation of the likely impact of a many-mile-long, high-voltage powerline, if it were in place, using 12 dimensions of impact, 42 critical characteristics of the cells, and a 30-year economic expectancy.

A Rural System Group, when developed (and even now), can supply a farmer or rancher information about similar impacts (defensive knowledge for protecting land from invaders of all types), but also about suitable crops, best grasses, likely forest site index, probable runoff, and holdings on request. The intent of such map-cell-specific databases is to bring to bear, on-site, the findings of science to make them relevant to the decision-making tasks of the owner. We have demonstrated that we have knowledge about and can be very particular, very precise, about land conditions. I now believe that the probability of any two spots (say, 10m x 10m Alpha Units) being alike, in any places in the world, is almost zero.

Thus, places for agriculture, the fishery, and forestry are unique. Because we now have or can cost-effectively create and manage such databases, and have sufficient computational power to analyze them (even on desktop computers), we no longer have a genuine need for a gross land statistic.

Even in developing countries, the ability (if not the motivation) to develop such systems cost-effectively is now available. Ease of use increases rapidly. Classification was once needed by the manager who took samples and made maps in order to form general pictures as the basis for making site-specific decisions. Now we have the knowledge of each site, with sufficient detail to assert the uniqueness of each spot on Earth. We do not have to make the reverse trip to generality!

Even though we cannot visit every spot in a region or large farm, it is possible to compute, in reasonable time and at low cost, the characteristics of every land unit, (the suggested Alpha Unit) using relative elevation, slope, distance to streams, gross soil texture, past land use, primary land cover, and time in shadow each day. Some of this spatial data is already available.

By more situation-specific work, some risks can be dodged. We must shift from generalized regions to specific, unique map-cell studies. The shift will not occur rapidly, given the historical evidence for changes, but current general knowledge can be used to “fill the knowledge about each cell” and it can be improved with models fairly rapidly… then gradually improved with several feedback procedures.

A little-acknowledged dimension of land analysis and prescribing uses is that *nearby features and forces* have more influence on plants and animals in a spot than on-site factors. Shadows and the presence of water in dry areas are examples. We can use the lessons of landscape ecology to relate “nearness-to” or “distance-from” ideas to an exact site. One Alpha Unit of land, five miles from a National Park, is a very different piece of land from the “apparently identical” one *inside* a Park.

Progressively, we shall be able to add a set of distant, but influential, factors to knowledge about each site. There are other factors that are invisible and not present on a sampling site, but we attempt to measure and note these with increasingly more perceptive and accurate technology (e.g., geomagnetic, solar, and tidal forces). These factors may play leading roles in the conditions or actions of things we now call “ecosystems.” There will always be other things that are active in our systems, at least within the Alpha Unit, and we shall attempt to accommodate them in our measures of statistical variance, and to live with the unexplained or so-called “random” (sometimes even “mystical”) forces.

Data Collection

If site visits to the land are impossible in real time, satellite imagery of only limited usefulness, and funding unlikely to increase substantially, then what are the alternatives for the nation and its scientists? Certainly, better planning is one answer (and use of remote sensing technology). Research direction and leadership, a past anathema, will be essential in the energy- and money-short future.

Far more attention must be paid to sampling in time and space. In the rural community, we need to abundantly use computing to determine sample size (n), with the best current knowledge all within a system with abundant feedback over time. Within this development there is reason to be hopeful about the future.

Optimization

Like many words loosely used, "optimization" sounds good, but has some hidden evils. To me, it means a mathematical process of analyzing a system and finding a condition in which all of the variables, when in the right condition, produce a state that achieves the stated or designated objective. The procedures always require a very explicit objective, typically to maximize, to minimize, or to stabilize.

Suppose we want profit from bread. We know the ingredients. We solve the equation for bread-making, attempting to maximize the net gains from buying ingredients, mixing them, baking, and selling bread. The objective seems fairly easily stated. We can imagine mixing all possible combinations of flour, yeast, etc. at different costs to produce different loafs of bread. Some will be expensive, some taste bad, and some "flat." Each will have an approximate price, including zero for those that will not sell. We can study with the aid of a computer, as needed, all of the costs and all of the "output" loaves and their selling price, and state an optimum.

Even a simple problem of profits from good bread can become very complicated if profit is an objective. My experience in natural resource optimization is that the formal computer-aided process can usually suggest a 10 to 20 percent better solution than a human's best guess. In bread-making, a 10% difference in profits can attract attention from investors. I'm convinced from reports of others that improvements of even greater magnitude are waiting within natural resource areas. I know of reports that managed lands can produce twice the profits of unmanaged lands.

I do not know why aids have not been sought, but I can list reasons: unaware of the potentials, the methodology of optimization is difficult, there have been few demands, many variables, not all variables are easily quantified, and there is no expressed objective. I think the last reason is dominant. What exactly shall we maximize? or stabilize, or minimize? What of the risks, the startup capital, and who will supervise? What’s a reasonable planning or investment period? What is the percent return on the investment? What is an unconventional or unexpected variable not included?

Forestry boxed itself in years ago, with "sustained yield" slogans. (Modern groups persist in going down the same dark path with “sustainability.”) One interpretation of the slogan is that the goal is for there to exist a constant supply of wood from forests. “Constant” or “continual” or “continuous” are words with different meanings, but no matter what that word is, the intent was for wood production. Sustained wood production when prices are falling can lead to bankruptcy! A lumber mill with no market will be very quiet, very soon. The point of this comment about sustainability is only that it is very difficult to state objectives within rural or wildland and other natural resource fields. "More deer" confronts "less deer damage to crops and seedlings"; "more wood" contests "declining prices for over-supplies"; and "better roads" for some recreationists must go up against "closed roads" for other recreationists.

Conventional decision making requires an objective. Optimization can occur only after such decision making about such an objective. It has been very difficult to formulate objectives within rural land management circles. Without a clear objective, then any solution or set of actions can be argued as satisfactory. With no destination in mind, any trip...or staying at home...is equally as good. "Good" has typically produced the response: “as compared to what?" and the answer, after much discussion, is usually "as compared to *this* set of objectives."

Some farms are said to be “marginal.” They exist on the fence between profitable or not. Being profitable is the objective. One dollar, more or less, determines on which side of the financial fence they may exist. On one side, they fail. Some owners move to the cities. Because the fence edge is so thin, the balance so precarious, it is easy to imagine how small changes in management, information and risk reduction can move people well past the margin. Perhaps Rural System work can be considered a counter-marginalization effort.

Temporal Aggregates

If we can stop thinking that each 24-hour period is a very precise number for our analyses of differences and change per unit time, we will improve our models, stop much awe over great variance, and reduce the need for saying “more research is needed.” Time is a human construct, an accounting mechanism. A “day,” however, is grossly amalgamated solar relations, cumulative lunar forces, average soil movements, etc. It is the intrusion of variance into the most fundamental assumption about time units that seem constant and controlled.

We must replace clock units with accumulated biomass, or Langleys of energy received, or food metabolized. Sunlight is strongly time-related, but it is not equivalent to time. As we study grass, crop, or tree growth, we know the major differences among seasons, elevations, latitudes, slopes, and aspect as they each affect the meaning of a clock-unit of day length. A day is a way of coding and recording when ecosystem radiation starts and stops, and each day is unique in its measured changing energy received at a point. It has no intrinsic meaning to knowledge of plants or animals.

Convenient and unlikely to be replaced, we need to substitute time (at least “days” and “years”) with one or more appropriate fundamental units, such as radiation within a solar day, potentially accumulated or received solar radiation. Whatever else was at work in the greenhouse, the lab bench, or the forest between 6AM each morning when the clock buzzes, is the unit for study, not a named unit called “time.”

Farmers discuss seasons being “late” or “early.” Ecologists study phenology, the study of the timing of biological events such as grouse mating, leaves falling, select plants blooming. In rationally robust work, including phenological time will help clarify chronological time, and will give that classical measure a new dimension, reducing claims of excessive variance in studies (and thus, the needs for more, expensive samples and their analyses).

Few workers in the environment know that they can gain massive statistical control within systems by knowing two factors: elevation and latitude. Slope, aspect, land form (ridge, saddle, etc.), watershed boundaries, stream channel location, stream order (and 20 established relations), and topographic indices (40 or more known relations) can all be computed just from elevation in cells across a landscape. Knowing and working with these fundamental relationships gives us great, rapidly developing modeling power, and control over potentially influential factors of the landscape.

Day length and radiation estimates can be computed from latitude and slope. Precipitation and temperature records can be adjusted based on nearness to multiple observation centers. Temperature estimates can be adjusted by solar radiation and elevation. The list of available models is extensive. Workers in rural systems need to gain a knowledge base of the key abiotic factors, the non-living "things" to which plants and animals respond. With amazingly few values, great predictive power can be gained over major system performance measures.

With site-specific models, optimization can be done for crop, plant, livestock, tree site selection, and production units. Plantation failures, and disease and insect epidemics, which are often the results of introducing a production unit into the wrong place… ***can be noted and avoided!*** We can improve existing models and create tentative models with much that we already know. We can probably advance more rapidly by using and adjusting theoretical models than by whining about excessive variance and decrying the lack of funds for curve fitting.

The knowledge base that we build will be within the models, documented, and changing as we cast ahead curves, find limits, bracket in coefficients, add variables and delete insignificant ones. We are skeptical of models now because they have not been used well, given far too much promise. Expectations were not fulfilled and the procedures were ceased, not modified, recast, or allowed to grow in light of new understandings, redefinitions, and reformulations. Data care and adequate modern storage were also missing.

Consequences

Every action in the rural lands has many known and identifiable consequences. A tree is cut, the soil erodes; as the soil erodes nutrients are removed from the area. "Nutrients removed" is a consequence of cutting a tree. Each consequence can be estimated based on studies and experience. (We do not have to do a study to confirm that water runs downhill!) Every action has many consequences, some more than others. The more we learn, the more connected the consequences will become. We decide that, admitting to consequences that we do not know or cannot measure well, we will deal only with a maximum of 5 levels of influence. Levels might be described through the tree example:

1. Tree removed
2. Shade reduced (insolation increased), temperature raised, wind velocity increased
3. Soil eroded, calcium leached from the area, litter decomposition slowed, etc.
4. Average antler size (basal diameter) reduced
5. Hours of quality-weighted hunting reduced

We can imagine several more levels—effects on plants, then effects on insects feeding on them, then effects on pollination, then effects on contributions to the mix in the litter layer, and others... These are the studies and tales of ecologists that believe that everything is connected. Many things are, but within this concept of *the satisfactory condition*, everything cannot be known; there is no time or money for studying everything; many things have effects that are not significant, not connected quickly. Decisions are to be made in a timely fashion. The time to develop a meaningful consequence table for every major action can be very long… too long. The computer analysis may take only a little time but preparation for the run can be costly and delaying.

A planned rural resource knowledge base must eventually embrace plants as well as animals, soils as well as forests, geology as well as climatic factors. There is no logical separation for topics of wetlands, watersheds, coastal zones, and precipitation of the water budget. Is a plant in the gut of a deer a part of the animal or exclusively a part of the plant world? I think that “wildlife” in the past has meant all wild life. In order to manage plants well, a great amount of knowledge is needed. All factors about each plant cannot be learned in separate studies. The plants themselves remain enigmas. Where one species stops and another starts is still debated. Genetic discoveries dominate daily. Mobile plants, such as the liverworts, have animal characteristics. Plant forms and their characteristics differ on different sites. Trees of some species unite their roots, making clumps-of-tree-like-forms the relevant unit, not a “tree.”

A general knowledge base is needed, one that is rooted more in "expert systems" than in conventional taxonomic keys. So much has been learned of plants over time that many generalizations can be made. There are many fields of knowledge already in a computer information base filled with an expressed high degree of confidence. The entry has to be general because now we do not have the time or the money to continue our studies, plant by plant, species by species.

A computer simulation is said to be a means to compute answers to: "What if *this* and not *that*? What will be the changes?" and “What will be the consequences if I change this factor, build this roadway?” The consequence table is a report of multiple consequences of an action; multiple runs of a simulation. "What if I cut this stand of trees? What will be the consequences?" The consequence table is a means of listing the major significant areas for which a report is needed, answers provided and used.

It is important to realize that the words used can lead us astray. It may be that "consequences" are categories of interest, and maybe “rephrased objectives.” We may want to know the consequences of an act on the calcium in the soil, but we selected calcium because we knew it is vital to plant and animal growth and health. Stabilizing or increasing the supply of calcium may be an objective. Maybe we are only approaching objectives through the backdoor?

If the consequences of an action seem bad (by some definition), approaching an undesirable threshold, adding excessive costs, or requiring major capital developments, then the action can be viewed as bad and, hopefully, not undertaken. The answers suggest whether the person or group will be able to remain within "the box." People want to know what will happen, what will be the consequences of proposals or actions. They know full well that precise statements are usually unwarranted, so they will ask for the "odds" or for probability statements. Progressively, rationally robust work engages in using computer simulation to produce consequence tables, expressions of the likely changes in the conditions of important objectives. They are needed to sharpen objectives and thus lead to optimization.

Equifinality

As a boy, I was more interested in "skinned cats" than in the wisdom of my grandfather's oft-used phrase: "there's more than one way to skin a cat." I could not imagine why there were so many such events or that a saying would have emerged. Unquestioning, I waited, for I had heard the non-answer enough times: "you'll learn one of these days." I think I have learned and I want to share knowledge of equifinality, because it has provided me many new insights and a pattern for some explanations (and related actions to be taken) within the rural environment.

A concept within general systems theory, equifinality deals with the observation that there are often several ways to arrive at the same end state. In arithmetic, the example is clear.

To get 9 we can multiple 3 by 3. We can also get 9 by dividing 27 by 3, similarly by adding 4 and 5. Different numbers and processes can lead to the exact same outcome.

This is true (but rarely noted) in the rural land sciences. There are many pathways to a mature oak tree, an adult deer, a mossy rock. A lot of water and a little fertilizer can result in the same crop yield as a little water and a lot of fertilizer. The emphasis here is that there are many ways to get to a desired end state, a position near the center of "the box." Many different abilities, tastes, backgrounds and experiences, even objectives, can exist within a group as long as they recognize the space that they occupy as suitable.

Analyzing pathways to determine equal crop or tree responses, or finding the "best," or "optimal" pathway (most cost-effective, etc.) are typical problems in agroforestry. Finding the absolute pathway or combination and sequence of factors may be time-consuming and expensive. Inputs to a system can change over a fairly broad range and still yield almost the best result. An important concept to be followed is that there are ecological thresholds in rural systems, e.g., most natural areas of the world will produce no more than a certain limit of phytomass.

The study of equifinality can provide new insight into the importance of objectives. If total tree fodder for farm animals is the objective, then there are many pathways to that condition. It may be that even after redefining the objective (e.g., total forage vs. percent digestibility), different conditions may produce the same particular end result. The need is to select a means that will maximize or minimize the results from among the permutations of these ways. In rural systems, each permutation is a potential pathway to the same end, one of many pathways of equal or often insignificant difference in costs or other criteria. (The number of permutations of 10 items is 3,628,800.) There is a vast area of financial and other indifference. The search for the best one, or more likely "ones," among the pathways will serve well.

When we do sensitivity analyses in the rural arena, we find many factors to which the system performance measure is insensitive. We can change inputs to the system over a fairly broad range before we reduce optimum conditions.

We believe this observation has evolutionary and survival-value roots, but the point is that it is irrational, counter to the available evidence, to believe that very great precision is needed or will be useful in work in the field with most factors. Of course, it will be irrational to fail to look for those factors to which the system is most sensitive or to fail to use those that are found with care or "by mistake."

Regression models of statistics result from making field observations and relating a factor of interest to some likely causative factor. The goodness of the model is judged on the basis of the statistical R^2 value. The closer the R^2 value to 1.0, presumably, the better is the model of the relationship, for the higher the R^2, the greater the variability that is accounted. I have seen vast amounts of field data scrapped because they "didn't shown anything" (i.e., the R^2 was too low). Not at all hostile to regression analysis, I find the concept of equifinality suggests the:

- enough samples (in each class, therefore in total) will rarely be available,
- there are threshold and non-linear phenomena at work behind every tree stump,
- a low R^2 is a reasonable hypothesis in the woods, and
- alternative managerial modeling approaches (e.g., expert systems) may be more useful than regression analyses.

"Biodiversity" lurks around every pillar in conference halls. I have a computer program with 18 ways to compute diversity (which I now call *variety* because of the diverse definitions of diversity). I can change numbers (e.g., simulate stocking 50 animals of a rare species) and see what happens to the index. Invariably, changing the animals causes 9 of the biodiversity indices to increase, 9 to decrease! The frequently-used Shannon-Weaver index is notable for its ability to produce the same index from very different numbers. A community with 55 animals in each of 10 species has a diversity index of 0.23... as does a 3-species community with 50, 100, and 400 animals in each species. The index is descriptive of an end state.

The details of estimating diversity are not at issue here. It can be comforting to know that there are several ways that it (whatever *it* is) can be achieved. It can be comforting to lawyers to know that the biodiversity index "sword" has 2 edges that cut both ways. The sparkling edges, points of lights, will be of little comfort to those claiming in court that diversity has not been achieved or maintained. There is a great amount of very difficult work ahead on the concept of diversity as a system performance measure and its estimation. I suspect there are several characteristics of the desired end state loosely and too hastily expressed by "diversity" and "biodiversity," words now in the law.

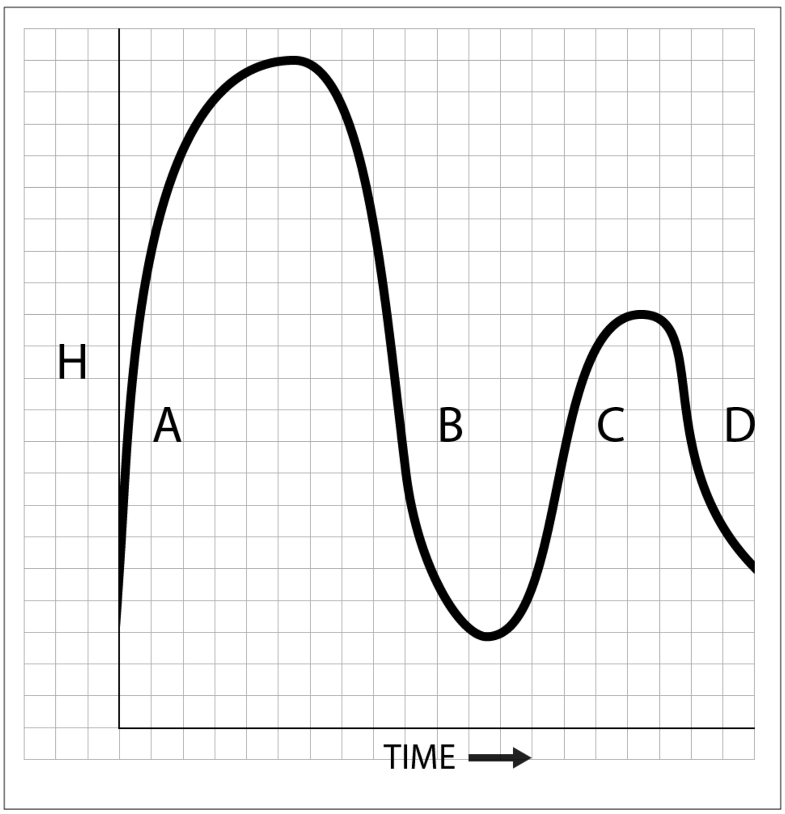


Figure 12. Computed system performance is identical at A, B, C, etc., although quite different factors may have had these results.

Cyclic natural phenomena are obvious examples of the same recurring population or economic numbers. Presumably there is one system at work producing the undulations, but the alternative (and I believe more plausible) hypothesis is that there may be very different phenomena producing the "curve." The end state, at points A, B, and C in Figure 12, are identical. They are manifestations of system potentials overriding constraints, and probably unique combinations of usually over 300 conspicuous, generalized working factors in an average forest or North American rural land. The potential relations (R) among this n = 300 factor system is merely R = n (n-1).

Ecologists are said to study relations. They may be irrational even to pretend to engage R relations (here only 89,700) as well as to work with n specialists.

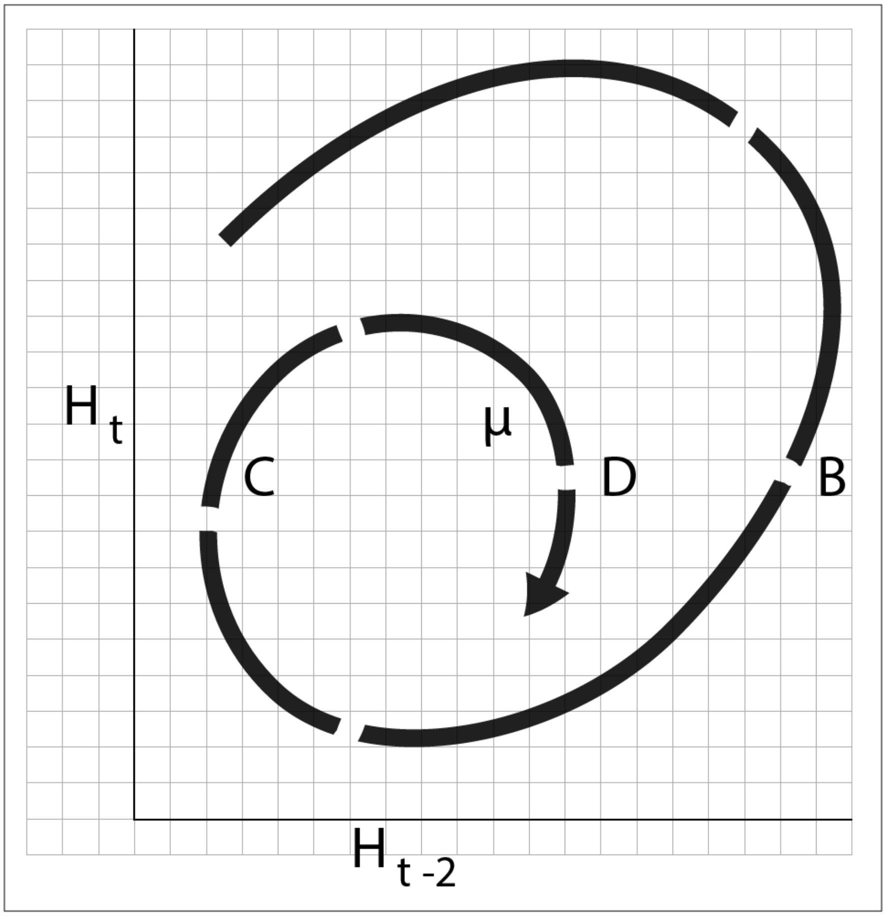


Figure 13. Harvests in one year are likely related to those two years previously. Equifinality occurs at B, C, and D. The mean, μ, is shown at the center.

Harvests in one year are likely related to those two years previously. Equifinality occurs at B, C, and D. The mean is shown at the center. Infrequently seen is a graph such as Figure 13, a picture of deer harvest as related to the harvest two years previous (often a strong inverse relationship). Equifinality results in nearly identical harvests as a result of three very different harvests as at B, C, and D.

These ideas (shown as cyclic or irruptive populations or as the circular so-called "phase plane") (Figure 13) can be combined to produce a picture in 3 dimensions that can be very instructive (Figure 14). If not careful or resistant, an observer may relax with the conventional wisdom of two-dimensional blackboard images. As seen in Figure 14, there can be many states of systems that are working that produce the "coil." When managers quickly generalize about systems, they often use the central tendency. This shaded center-core (Figure 14) does not exist!

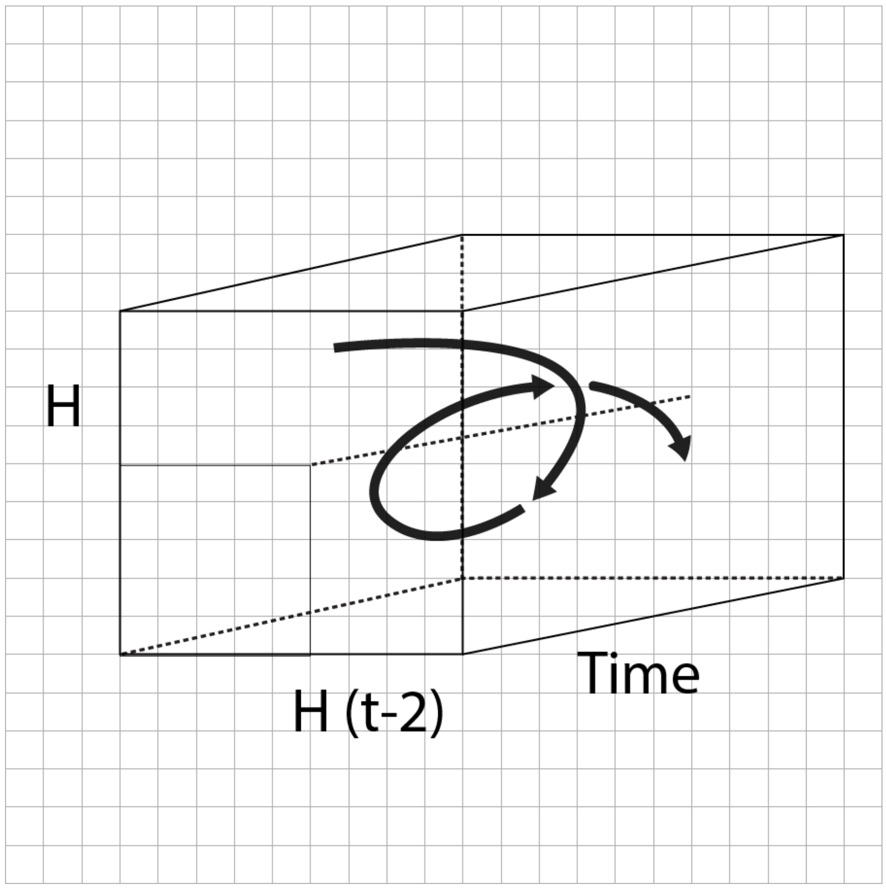


Figure 14. Information in Figures 12 and 13 can be considered in three dimensions. The central tendency is shown at the dotted core. The system may never occur in the central tendency, usually represented as an average statistic.

No point on the curve showing final states of the system occurs along the shaded line at the center. Equifinality is descriptive of the ways that points on the curve are reached. It does not describe how the non-existent center is achieved.

Forests and related natural resource systems are not 3-, but n-dimensional. Knowledge of the center space, the "central tendency," is not likely to serve practical, responsible managers well in the future. What can serve is knowledge of the systems that produce measurable ends. A step in that direction is to concentrate on the maximums and minimums observed. What comes next (or first, or simultaneously) is clear thinking and articulating the forest objectives—the complex, desired end state.

The rural resource system manager needs to assume that equifinality may and does occur in all complex systems. It often occurs in cyclic or periodic ecological phenomena.

Statistical tests of factors that affect some system output or end-state need to be carefully and reluctantly used. The Y variable (dependent) can result from many combinations of different Xs. A low R^2 is highly probable. Improved and reduced-cost sampling schemes can be devised.

All means to the same end—to some equifinal state—probably do not cost the same. Lowest-cost pathways need to be sought.

Range-Related Knowledge

Many natural phenomena are not normally distributed (bell-shaped line graphs). Because of this, the statistical median often better reflects central tendency than does the mean or average. When one value must be used for a factor in a 50-factor model, then the median should be used. The median has been effectively estimated in engineering and military work for many years and, although used to develop estimates of time needed to complete a project, we believe it can be used with low risk in other aspects of rural work when experts are available.

The principal advantage of estimating a median value is that estimates of parts of the equation for high, low, and likely can be obtained quickly from experts, available records, or observation. Intensive sampling and measurement is not required to make at least a rough estimate of the median. It is rational to use estimates such as this for crop production, tree yield, charcoal yield, animal weight, and other aspects of rural work. It is irrational to deny so-called sensory and authority epistemological bases of the people of the country and to ignore the growth, survival, and potential harvests and real benefits from forests, livestock, and croplands. We must deduce with feedback. Cost-effective development of dominant relations among all major biological and social factors seems reasonable.

Maximum and minimum values are often easier to establish, and may provide more information about natural phenomenon being investigated than an estimate of an average or mean. It may seem unreasonable to use statistical range, for such use seems to relax our efforts to achieve great precision and ability to discriminate. However, hope for gaining knowledge lies in using the ranges and also increasing the number of dimensions of an analysis, not, as in past studies, in emphasizing increased sample size and precision in only a few dimensions. The result of using ranges will be to limit the sample sizes and, thus, time and costs.

The observations of the range include those from a global maximum (e.g., the maximum temperature ever recorded by any weather station in the world), to a regional maximum, to a stratum maximum. Bayesian analysis suggests the practical use of *a priori* knowledge of such phenomena as maximum temperature in a study area. The probability of two states of nature, above or below the range limits, can lead to a set of values (perhaps in a uniform distribution) that can be used within computer models. By such use, sensitivity of the system performance measure or 'success score' to each variable can often be determined. Eliminating variables that need further study or that must be expressed precisely can lead to major savings.

There is a feeling, generally, that knowing the range of values for some aspect of a system provides little information for decision-making. In ecological systems, functioning over very long periods, what is *now* observable as “the system” is really the “remainder” of plants, animals, etc. after extreme or episodic events. (Those surviving are said to be “fit.”) Because of this, the range is probably the best value for use, especially while the “long-term” and the “sustainable” system phrases gain political and research-agency-support vogue. Ecologists see a multi-dimensional space within which people or plants or other animals may exist. The walls are the outside limits to where they occur. The walls are the ranges. The space is called the creature's "niche." Endangered species have very small niches.

The ranges from field studies of rural factors of interest can be mapped within GIS software. All work to date, using more than seven variables, has produced maps of great complexity, detail, and counterintuitive patterns. These maps seem to provide at least as much resolution for decision-makers as conventional yields from statistical analyses.

Many factors that operate on crops, trees, or animals suggest a feasible space or defined hypervolume within which they may survive, production may occur, or profits may be obtained. My emphasis is that ranges are important; an optimum might be found, but computer searches and field tests need to first address the space defined by feasible or reasonable upper and lower limits of all relevant factors.

Tentative Confidence

Almost everyone likes to make decisions with high confidence (or a probability of 1.0 minus risk). People desire low probability of "being wrong," but there is ample evidence that they do not behave in a way that is consistent with such a theory. People marry with fairly low confidence for success (by several criteria). They make household purchases with only modest amounts of information about best options. Farmers or foresters rarely farm or practice forestry as well as they know how. Making decisions at some high level of confidence seems reasonable, but it is often inconsistent with human behavior.

Risk-taking behavior is never singular. It is always a combination of a perceived probability and the effect of the consequence of being wrong in the present instant or longer future. The consequence of being wrong may be thought of as the combination of the effect on an individual, the number of individuals, and the magnitude (especially over an area) and duration of the effect. When confidence or the probability of an error is computed separately, meaning of risk for a farmer or a community is lost.

Scientists, the community, have adopted an arch-conservative, risk-averse paradigm in the standards for confidence in their micro-environment, tightly-controlled experimental decision-making. That paradigm has been taught and widely accepted, insisted upon for human drugs, generalized for everything else, and thus the general educated public now has excessively high, excessively costly, excessively delayed contributions of "science" to decisions.

Most rural research is stuck in a 95% probability rut. Taught in college as proper, the level influences decisions throughout many aspects of rural decision making. The perception is that we can tolerate an improper decision (e.g., whether crop production was significantly increased by under-planting vegetables within a grove of trees) no more than 1 time in 20. Given that 10,000 such experiments have been done in the past 10 years, then 500 erroneous decisions have probably been reached. People concluded that there was a significant difference due to fertilizer or irrigation when there was none. The reason that the possibility of 500 mistakes does not bother many people is that they seem to know at a high level of probability when something *did* have an effect. They are more confident than 95% even though the test statistic is only working at that level, the 0.05 level.

While we would all like to be absolutely certain of almost everything, i.e., decide at a confidence level of 0.9999, such a criterion is unreasonable and excessively demanding in most Rural System work. For corporate boards or directors, a mere 5 to 15% improvement is acceptable. A stock portfolio must have only 5-15% gains as compared to losses or failures. A game population only needs to be "relatively stable." The population being over-hunted, for example, can be easily restored in a few years (often increasing in a post-hunt environment with surplus food and without crowding) or by simple adjustment in future harvest regulations. These observations about how other people deal with confidence or with acceptable levels of accuracy argue for me that it is unwarranted to assume that farmers or foresters operate substantially differently than they do. Using high levels of confidence such as an alpha of 0.05 (the 95% level) in most Rural System work is inappropriate.

Achieving high confidence requires typically great sample size, thus, high data processing, storage, and analytical costs, and produces results that are often inappropriately used, not reported, not stored, or not critiqued, and thereby violate many of the premises of classical science. The use of the confidence level as a separate statistic is inappropriate; it must be unified with effect, people, and time. A much lower alpha level needs to be adopted on the grounds of appropriateness, high expense per sample (in all dimensions), inevitable alternative sources knowledge, and on the grounds that rationally robust work involves a clinical approach, one with active feedback over relevant time.

Simple computations can demonstrate the high costs resulting from establishing inordinately high requirements for confidence and tolerable error in studies. The statistics of brief, controlled studies do not apply to the rural situation. Assuming that they do apply may more than double the costs of studies. Given the massive needs over vast areas, the extreme pressures on resources, the desire for answers as quickly as possible, the extreme shortages in money and expertise for studies, the complexity of the problems and their analyses, and the relative adaptability and resilience of natural systems, confidence levels of 0.20 need to be used, followed with applications and adjustments.

Within rationally robust work, staff seek to find the fewest number of pieces of information (the system inputs) that, with regression and other models, give estimates for the greatest number of important Rural System models possible. Acceptable control over the system is judged when model goodness indices of R^2 values above 0.64 are observed.

Continuing species-specific, highly precise pursuits now seem inappropriate. Perhaps other people, who continue classical studies, may contribute to Rural System work and knowledge. Knowledge, however gained, will surely be welcomed to improve estimates throughout the complex models that will be used.

Looking Back

Herein, I've discussed some of the pathways to discover the role that science has in predicting futures. I've suggested a unified, humanistic concept of science transformed into rationally robust work. It has within it a concern for the time when discoveries will be used for people, the concept that research can buy society time in this critical period, and the opinion that society is likely to opt for more sequential than simultaneous work. To reduce the impact of this decision, it is important that rigorous research planning be given higher importance than ever before. Contrary to some who contend that prediction is out of the realm of science, I hold that it is presently well-within science, has historical roots in astronomy, and needs to be given more emphasis, not because of its shortcomings, but inclusive of them for the utility it has for shaping a reasonable environment for people.

This chapter is partially about heuristics. Roughly, as we discussed in Chapter 5, heuristics means the way one finds out or discovers. It is a long chapter and probably relegated to cosmic otherness, losses that might be tracked by learning-forgetfulness curves and probability functions for ideas accepted. The desire I have is that you, the reader, may later adopt and improve, perhaps reconstruct a personal rationale, a viable process of study and rationally robust work for people. You are encouraged along my tortuous, conceptual path toward the ground for hope for the future of rural people.

The entire Rural System enterprise can be viewed as being focused on a desired future and that is dependent upon rationally robust work. That includes explaining and making predictions about the past, estimates of the future likely to function similarly. It involves more than this, for making decisions and implementing them, assuring their performance, and then managing the results is the enormous work ahead. It is in understanding of these functional relations, using them in synthetic models with high deductive skills, that the future can be known, that consequences of acts can be seen and evaluated before they are performed, and that the future world can then be shaped as a proper place for humankind.

About the Author

While many Americans are presently astonished at conditions in rural America, Robert Giles, Jr., Ph.D., has been working tirelessly for decades on planning solutions to interconnected rural problems. Dr. Giles is a Professor Emeritus of Wildlife Management at Virginia Tech where he taught for 30 years. His Bachelor of Science degree in Biology and Master of Science degree in Wildlife Management are from Virginia Tech. His Ph.D. in Zoology is from The Ohio State University.

Dr. Giles was born on May 25, 1933 in Lynchburg, Virginia. He attended E.C. Glass High School, during which he was awarded a Bausch and Lomb Science award for studies of the ring-necked pheasant. As an Eagle Scout, he was awarded the W.T. Hornaday National Award for Distinguished Service to Conservation and the James E. West Scouting Conservation Scholarship. During his undergraduate years at Virginia Tech, Dr. Giles was an editor for several magazines and the president of the V.P.I. Corps of Cadets of 6,000 students. He was also a member of seven national honorary societies.

During his time as a Professor in the Department of Fisheries and Wildlife at Virginia Tech, Dr. Giles was known for his innovative applications of computer programming and Geographic Information Systems (GIS) to land management questions well before such skills became standard practice within the field (and before GIS was a term). With the support of the Tennessee Valley Authority (TVA), he created the woodland resource management system of TVA, once used on 300 farms a year. With staff and students, he created the first wildlife information base (BOVA – Biota of Virginia database). As chairman of a local planning commission, consultant to the National Wildlife Refuge System, aid to the State Cooperation Commission, consultant for Wintergreen and several realtors, and as a landowner himself, he has developed a unique and alternative perspective on land and its management. He wrote the first plan for wildlife other-than-game for Virginia.

Dr. Giles began working on the Rural System concept in the early 1980s, but did not begin in earnest until his retirement in 1998. When asked about his aims for designing Rural System, he said, "I am now convinced that a superior demonstration of modern comprehensive natural resource management is badly needed and is now possible and most likely within the context of a new corporate rural structure. I do not want to do research. I do want demonstrations of the results of literally millions of dollars of unused research findings. I propose to bring all the power of the computer that I can to realistic and relevant use for parts of the region. This will include using that power already achieved by investments of resource agencies. I propose a system, subject to the law and to reasonable issues of cost, propriety, and community acceptance, that achieves such objectives."

A colleague of his once said that Dr. Giles can come up with more ideas in an hour than most people can in a lifetime. His creativity is exceeded only by his humanity. Raised in Southwest Virginia, Dr. Giles knows the struggles of people in Central Appalachia, impoverished after the collapse of coal and tobacco industries. He has visited rural areas of Africa (Nigeria, Senegal, Uganda), China and India, and is well-educated in the sufferings of people in poverty worldwide.

Dr. Giles is a systems thinker. He believes that the problems faced by environmentalists and those of interest to humanitarians are interconnected, and that a system of problems must be met with a system of solutions. His career, his values, and his innovative capabilities make him uniquely suited to tell the story of how a for-profit systems approach can best solve the rural problems of a progressive, capitalist society.

Contact information:

Robert H. Giles, Jr., Ph.D.
509 Fairview Avenue
Blacksburg, Virginia 24060
United States of America

Publisher:

Handshake Media, Incorporated
http://www.handshakemediainc.com
contact@handshake20.com