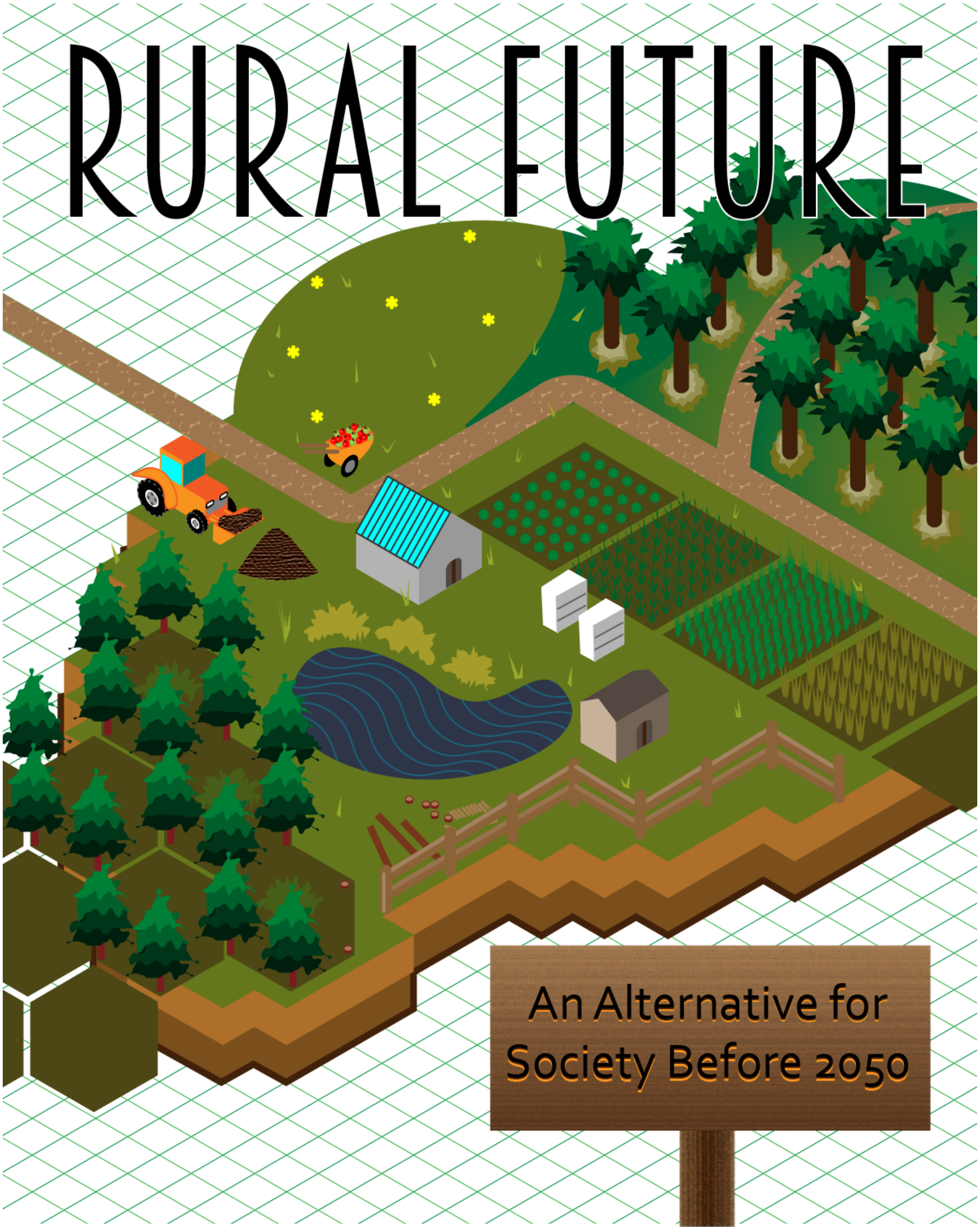
RURAL FUTURE
An Alternative for
Society Before 2050

# Rural Future

## An Alternative for Society Before 2050 AD

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# Feedforward: Prediction and Now-Action

*Feedforward is action today within a system to accommodate well a likely future period or condition. No, it's not future-telling. It might alter a future condition, but that's not its function. Feedforward is a word with conceptual usefulness in the systems approach of Rural System.*

Plans are about the future. A plan may exist for the present, as in "I have a plan," but it addresses the future. One element of superior plans is **feedforward,** best understood by comparing it to feedback. The best popular example of feedback is the thermostat in the house. It is a procedure that senses the temperature, compares it to the desired temperature, and holds-fast or changes the furnace or air conditioner functions until the desired temperature is reached. It is one named "thing," but it is composed of several actions.

Feedforward is a parallel concept; it predicts the future, compares it to objectives, and makes adjustments in the major elements of the present system so that the total system will be very responsive over time to predicted future conditions, as predictions change. Foresters are among a special group of people who must use feedforward in society. Predicting the future and planting trees for that future is one of the most long-term projects, with estimated payoffs far outside of the limits for most current businesses.

For example, if a forester predicts rapidly-growing interest in a special type or color of wood, he or she might re-forest appropriate areas with those species of trees. In effect, they would be getting ready for the predicted future. Feedforward is not a "prediction" or a "forecast," but the total process (a mini-system) of *preparing now* for the future.

In another example, a building may be needed, and the number of people to be eventually served is estimated to be 200. The costs may be too great to build for 200, and no more than 100 would be served in the first 5 years. A building is then built for 100, knowing it is too large now (there are only 40-50 initial users), just right for 100 later, but ultimately too small for the growing group. Feedforward involves taking risks and using careful analysis of the meaning of being "most right over the long-run." In some cases, average annual performance will be a good measure. In other cases, there is a need to keep the deviations (e.g., peak loads) small.

Another example is very important for some agencies and programs. A plan is written. It is reasonable to write several scenarios for the future, i.e., if certain laws or policies (now in the "hopper") are passed. We know future conditions will be different; we even know that the change agent is active. We must put in the *present* plan the responses to the several limited likely futures. This is a specific act of feedforward.

No one can know the future. Feedforward was omitted from early development of general systems theory, for it was unknown in biological systems. Yet, the future can be estimated; estimates about the future are called "predictions." Some things are known at such a high probability that they can be assumed to be known (e.g., water running downhill, the sun rising). Otherwise, it seems reasonable to discuss the *probability* of future events.

Some psychologists believe that some people never reach a stage of mental development or maturity in which they can see or imagine the future. Few people buy insurance, implying some things about their expectations, concept of the future, and what, if anything, can be done *now* to prepare for that likely state. Few people have a "nest egg," partially because of economic conditions, partially because the likely future conditions, some pretty bad, cannot be very real to them.

There are methods and procedures for improving future decisions, by going beyond collecting data and analyses and using them in decision-making. These methods include:

1. Using continually updated and improved models;
2. Using linear and non-linear regressions and trend analyses;
3. Using Delphi exercises (sharing of estimates within a group of experts);
4. Conducting conferences with discussions and special lecturers about the future;
5. Holding essay contests and making writing assignments about future scenarios;
6. Holding contests about future trends, ideas, innovations, and desired conditions;
7. Reading *The Futurist* and related magazines;
8. Holding "limits" discussions to seek and describe limits and the consequences of nearing or reaching them;
9. Holding "perturbation" discussions, examining the likely consequences of major changes caused by people, technology, or nature; and
10. Doing retrospective reading of the Transactions of the North American Wildlife and Natural Resource Conference (and similar records).

An example of a change analysis is that related to a sharply decreased supply of nitrogen. As a result, more areas in farms are needed to produce the same amount of food, reducing forests and wetlands, thus leading to more intensive use of some forested areas, and less intensive use of other areas (e.g., old growth). A similar pattern might be used with decreases in the supply of phosphorus, thus major decreases in crops. Reduced amounts will be in ponds, and thus reduced eutrophication. Crop wastes will decrease due to the shift in production …with wild faunal effects.

Feedforward includes the special concept of a failsafe action or operation. Depending on how sensitive a system may be to failure, or how harmful will be the consequences of failure, backup or failsafe mechanisms are needed. The failsafe action looks ahead, attempts to describe worst-case scenarios, predicts the consequences, and then attempts to take action at reasonable costs that will prevent such failures. A police person or agent traveling with another agent as "backup" is a simple example.

A modern agency, failing to get a license increase, will likely have a failsafe mechanism. Endangered species, for example, may need intensive protection by officers, but this may not work or be insufficient or may contain lapse periods of no protection. A protective fence may be another simple example of a failsafe mechanism for this problem. An officer carrying two guns and an educator carrying two projectors are other examples. For truly important events, double backup is always suggested (and even that may fail, but the costs of further backups can rarely be justified, given the odds of multiple failures). Practical people on tight budgets will rarely tolerate having around apparently unused things, the backups for the things in use.

Feedforward seeks to estimate or comprehend the future, and then to revise the present system based on that perception. It is not just future-telling (any more than a thermostat is just a thermometer). It is not prognostics or futurism. It is a multi-technique approach to seeing the future and acting today to adjust the now-system to meet these tomorrow-system conditions. Much needed, nevertheless some land owners are put off by the notion that feedforward makes today's system wrong or sub-optimum, but allows the system to be most-right or least bad—optimal—over the long run (however defined or decided).

Computer programmers often use feedforward. Building a software program now, with a view for the future use and other uses, and with a means to add easily a new module (scalability) or with an extra translation program to unify two programs are examples of using feedforward. The common situation is that a present program is bigger and better-documented than it now needs to be, and thus inefficient. However, seen as feedforward, over the long run its eventual expansion and completion may be *very* efficient. Estimating the future and taking action *now* to respond to that future is a very human activity—nowhere else present in nature.

As a more specific real-life example, I hired a person a few years back to work with me on the Rural System concept and development. Unlikely to gain capital for the continuance of Rural System in a timely fashion, I still asked her to write, for Rural System, a paper on her specialized knowledge and experience in disease ecology. I wanted notes as they might apply to reducing risks, costs, interruptions, and even legal action in the future for Rural System and its managed ownerships. I had seen and heard of minor oversights and omissions of well-meaning "environmentalists," whose actions did much more harm than their years of well-meant field work … because of just such a blind-spot or omission.

I committed wages because the strength of my belief in the *future* of her successes and in the active use of her *to-be-written* text in future work. I spend very real, limited funds in the present with great doubt and (scientist or not) no way to *know* the future. There is amateur feedforward optimization involved, balanced investment now for highly probable and highly-valued knowledge and payback for about a third of the 150-year planning period, moving forward.

# Chapter Five

## How Do I Know Rural System is “Right,” or the Best Option?

With looming limits for food in 2050 AD and water in 2030 AD, effective, responsible natural resource management is more important than ever. How do you or I or anyone know whether Rural System will be effective in meeting the desperate needs of global peoples for water by 2030 AD and food by 2050 AD? To answer this question, we will share our approach to gaining and using knowledge. We encourage you to apply the epistemological tools we discuss in the next two chapters to evaluating Rural System concepts, and to presenting your own ideas for solutions for the rural future.

Many of the most important modern environmental problems result from human activities that threaten Earth's life-support systems. Habitat alteration and destruction, species extinction and overall loss of biological diversity, stratospheric ozone depletion, and global climate change rank among the most serious of these problems. To a large degree, the problems are ecological in nature, but they are also simultaneously economic, esthetic, and are strongly rooted in energy availability and policies. An integrated policy, planning, and management framework, based upon the best knowledge that can be provided from the social and environmental sciences, is needed to deal with current and emerging environmental problems.

The rhetoric that pits the environment against the economy is a false dichotomy that can be replaced by the emerging view of opportunities within Rural System, resulting from the strong linkages between the environment and the economy. A challenge is to manage natural resources and the environment in a manner that provides for both the evident needs of today and those now emerging. Decisions about natural resources and the environment have long-term and short-term economic consequences. Experience demonstrates that managing environmental systems in a sustainable fashion will be economically advantageous in the long run, but balancing economic development and the management of environmental resources remains one of the greatest challenges for any region.

Since the late 1960s, when environmental issues first received notable international attention, the discipline of ecology has made significant contributions to peoples' understanding of environmental problems. In the 1990s, the ecological community developed an intellectual framework for acquiring and disseminating ecological knowledge required for developing many resource systems to provide for human needs. Rural System builds on that framework—a rational basis for analyzing systems, designing them, and for identifying important areas for ecological research.

A comprehensive, environmental, knowledge-base-building program is needed to produce or gather the data and deliver the knowledge required to make informed policy and management decisions, understand and minimize risks to the services provided by ecological processes, identify mitigation procedures and restoration strategies, and evaluate the economic value of so-called ecosystem "services”—all at a reasonable scale, cost-effectively. Rural System prioritizes:

- fully using our *current* knowledge about ecological processes when making environmental decisions;
- developing a strong knowledge base in those areas where the necessary information is currently lacking; and
- developing decision aids for using many large knowledge bases in making complex decisions.

If the region is to have the knowledge needed, the scientific community may need to adopt a Rural System approach to research, or more informal "studies." Rural System is devoted to *disciplined* inquiry. It will assist in setting research priorities, conducting efficient, planned studies, communicating the value of research results to the public, and providing sound information to policy-makers.

There are three areas important to knowledge-base-building:

**Stable Ecological Systems** – answering questions at the interface between ecological processes and human social systems. We need to understand when natural and managed ecological systems are stressed to the point that they are no longer capable of being sustained for human needs, how to restore damaged systems, and how to manage natural systems so that they can remain productive to meet the needs of the human population.

**Biological Structure and Processes** – understanding how complex communities work. We need to know how anthropogenic changes affect ecological processes and results, and thus the benefits produced by outdoor systems.

**Global Change** – understanding the ecological causes and consequences of global change, including climate change.

The inextricable links among the region's economic and environmental well-being underscore the need for sound environmental policies and decisions. Complex environmental problems, with many factors, require a coordinated and comprehensive program. The importance of each part of such programs can only be known *after* decisions are made, "end-values" are stated, a priori, and results are resolved.[1]

## Rural System's Advanced Studies Program

John Dewey wrote that studies are "...The means for the continuous discovery of new truth and the criticism of old belief."[2]

Rural System is a relatively sophisticated system, now being planned for guiding managers in making difficult, often very diverse rural land management and economic decisions.

The land- or resource-manager is *not* an easily recognized person with common education, abilities, or on-the-job training. Many managers do not have the knowledge or experience that allows or encourages them to make the best possible use of the many products of the land—recent graduates of university programs may not have developed the necessary skills and abilities. Because of the new, sophisticated, complex demands of modern land use planning,

[1] Based on: Lubchenco J, Brubaker LB, Carpenter SR, Holland MM, Hubbell SP, Levin SA, Macmahon JA, Matson PA, Melillo JM, Mooney HA, Peterson CH, Pulliam HR, Real LA, Regal PJ, Risser PG. The Sustainable Biosphere Initiative: An Ecological Research Agenda. A Report from the Ecological Society of America [Internet]. [cited 2017 Apr 20]. Available from: https://www.esa.org/esa/science/sbi-agenda/.
[2] Dewey J, Boydston JA. The Later Works, 1925-1953. Carbondale (IL): Southern Illinois University Press.

few land owners have staff with resources for the timely and cost-effective development of such plans.

There are many people in public resource agencies without advanced degrees. Many need and desire them. Because of area locations, professional responsibility, and family circumstances, many employees who desire advanced degrees (typically the Master of Science) have been unable to obtain them. Rural System presents a need for such education and an opportunity to both offer and gain parts of it. One need may be met by having experienced staff intimately involved in developing Rural System. Coworkers will be needed to complete phases of the System, to capture past investments in diversified research and knowledge-building, and to encourage personal involvement with and loyalty to a quality system under improvement. Rural System will arrange for them to participate in a new **Advanced Studies Program**.

Professional biologists and wildland managers may apply to a local graduate school. Upon admission, they may take part in on-campus work, electronic educational experiences, computer-aided instruction, short-term intensive seminars, and may simultaneously create a major component of Rural System under careful supervision. This component would be equivalent to a master's thesis, and not unlike management plans, computer programs, or policy analyses already widely acceptable as part of master's degree programs in universities across the country.

The enrollee in Rural System's proposed Advanced Studies Program will not have to seek a degree, but may participate in any or all of the many resources of the program, including textbook discounts, information systems, computer resources, software, computer-aided instruction, tours, field trips, demonstrations, short courses, and electronic education of various types.

The results of participation in the Advanced Studies Program may be:

1. career development;
2. pride of "ownership" in parts of Rural System;
3. rapid development of Rural System;
4. quality inputs to Rural System from the diverse experience of participants;
5. lowest-possible costs for educating staff and building Rural System;
6. unique timing, scheduling, and an alternative pathway to an advanced degree if one is desired;
7. educational opportunities with general systems theory orientation (which is so highly relevant to land-use in *all* agencies and ownerships across the U.S. and the world); and
8. likely continuation of the planning process and an improved Rural System based upon it.

The typical participants will have more than 3 years of experience in rural land work—resource-related work in public agencies or within the private sector. They will present letters of recommendation for participation from their supervisor, and one letter from a former supervisor or person familiar with their work. They must have extensive rural experience (or present a rationale for an alternative pathway), and have an acceptable grade point average in advanced undergraduate courses (typically 2.8 or greater, in the last 2 years of a recognized Bachelor of Science in a related area). The applicant must develop a contractual relation with their supportive employer for at least 3 years of work after graduation (no matter how long the actual course of studies may require, since these hours will typically be on a part-time basis over many years). Pay-back provisions will be included for employees who move to employment in another agency, ownership, or organization position in less than 3 years.

The degree program will be designed for a "standard" M.S. program. Instruction will differ greatly from conventional programs. The time required is likely to be extended. The thesis requirement will remain, but the type will vary, for it will describe and demonstrate a working component or a major component of Rural System.

Rural System has a policy or philosophy of using studies and research. It rarely will *do* research, partially because it has a working hypothesis that an attempt has already been made to answer most highly-relevant rural questions, and that the job now is to find such reported work and use it ... at least in some approximate or tentative way, objectives-related.

We are struggling, still, with the means and with receiving the diffused knowledge. We believe research to be given far too much credit, and that there are many ways to know anything. *Induction*, typical of the scientific process, is only one way to know. We favor *deduction*, and then approximations used within models. We tend to believe that we know much about systems—that the parts vary, but that they can be approximated. The generalized results of good models will probably give us more useful information, approximations, and feedback appropriate for changing field conditions than the very best field research (always with its sequenced delays and inability to achieve required controls).

We know that within Rural System we cannot be against "science," but we appreciate Wolfram's *A New Kind of Science*,[3] and tend to hold that the uncontrolled, long-term, and highly variable conditions (many caused by people and exotic insects and diseases of the rural areas) are not appropriately addressed by conventional science. Perhaps that is one reason why adaptive procedures have gained such quick fame. Adaptive management, however, dodges the issues of *how* we know *when*, *if*, and *how much* to change ... or the appropriateness of the probability standard for the "after" condition. Adaptive management omits feedforward of the modern systems approach, and has little role for standback (Chapter 2).

There are major advantages of Bayesian methods for informing land and pond restoration and production decisions, especially about lands and waters in transition. Bayesian analyses are providing innovative solutions to research and policy problems commonly faced by environmental scientists and decision makers. Two distinct advantages of Bayesian analyses are that they allow expert knowledge and knowledge from other, similar situations, to be incorporated in the form of *the prior*, and they characterize total uncertainty in a compact and useful way via *the posterior* distribution.

While expecting to exploit the vast, hard-won resources of past research findings, we will engage in specialized, directed studies. Research has provided information and conclusions that have become the basis for much of the analyses, decisions, and content of Rural System and interior Groups. Research is seen as a subsystem that provides inputs to decisions. It is one of the ways that people come to know things, one major way among 10 ways of knowing discussed herein, and includes inductive and deductive methods. Research needs to be continued in a strategic way, *a system of studies*, on carefully-selected topics that will allow informed changes to be made in profits, *very* cost effectively. Results of past studies need to be used in the system; results need to be synthesized and used together. Data and photos (etc.) need to be protected, and all must be backed up. All results need to be brought to bear on area decisions; preliminary and pre-publication reports are essential, and part of an evolving, named system.

We are aware of how limited we are, and how short of time for additions and developments. It is very hard to predict ecological events and their consequences very well. The systems are very complex, well-known to have many parts, most of them varying, and there are

[3] Wolfram S. 2002. A New Kind of Science. Champaign (IL): Wolfram Media.

many biological linkages and sequences. We remain unhappy with the fairly persistent but un-sustained investment in measuring rural resources and developing predictive models. We intend to participate in changing such conditions, with work to meet our needs and to demonstrate the great potentials from such spatial and temporal studies, related to future production potentials.

We are especially interested in "sequence" of presence and action as an important factor in our systems, perhaps more-so than the conventional, readily-observable factors that we now include in our models. We hold that economic analysis will be the bridge being built and used in Rural System *between nature and the people of rural areas.*

## How Do We Know Anything?

How do I or other people know anything? Not "what" or "who," but *"how"* do you know? I surrendered long ago trying to answer "What do I know?" for others graded me on that—both its number and magnitude—and found me, as I knew, wanting.

Then I encountered the question of "How do I know anything?" and I continue quests for those answers. I've learned from others that there are 11 ways to know anything, maybe more. Probably there are only alternative or preferred groupings of ways, called by some "criteriology" or "epistemology." I assert no creativity, only a collection of ways or criteria useful to me (and hopefully to those of Rural System) to know the topics upon which we all now rely.

Criteriology leads to images of "truth" being within bounds—a "ball-park"—or within the volume of a multi-dimensional, multi-faceted, high-truth or high-belief object.

Words are not adequate for many topics. Pictures, moving ones, 2- or 3-dimensional, may suffice. Poems are said to serve in special ways. Different languages handle topics better than others because of the available words, techniques, and their long-accepted uses.

"How do we know?" may be a question answered best (for one meaning) by saying, "read chapter Z in book K," the book's author(s) referring to a criteriological base of authority. "How we know" may be a topic for a psychologist, or better yet, a neurologist. An anatomist may be correct in pointing to the exact part of the brain where dimensions of knowing occur.

I hope you will not diminish the question. For the future of the rural world and its people, all of us need to know the ways that people know as rapidly as possible. We must struggle to use the most appropriate ways in the most refined and discriminating ways possible. We need to move the condition of knowing onto the platform of action, of rational robustness, discussed in the next chapter. We often assemble "what we know" with "how we know," because we assign different weights, strengths and confidences, or sets of limits, to each thing known depending on how we know it. Even more importantly, for some questions, we assign a weight of strength and probability to each knowledge base.

The knowledge bases for Rural System use are:

- Authority
- Other
- Genetic
- Place
- Private
- Sensory
- Contextual
- Coherence

- Pragmatism
- Induction
- Correspondence

Each will be described in the order listed.

**“Authority”** is knowledge based on a power figure, some fount of truth. This is knowledge asserted by the expert or an undisputed source. It may also be a group authority, such as expressed in a creed. Primitive examples are the medicine man or wise person of the tribe. Modern examples are the authoritative text, a senior committee report.

Although limited, authority is a way to know. People who have worked afield for years as trained observers know an enormous amount. It is very sad to see environmental agencies not attempt to capture this knowledge when these people change areas or retire. (In Rural System, this problem is addressed in **Nature Seen** and **RuraLives**.)

“Authority” is weak as a base because it cannot handle the prophet or the spurious observation, and it cannot discriminate between authoritative groups. Parental authority is enough to make many people leery of this base. A sub-unit of authority is "privilege." "How do you know her salary is that much?" "I know; I am her supervisor." Not necessarily experts, some people have special or privileged access to information that others do not.

**“Other,”** a modest escape valve for knowledge hidden from me, indicating means of knowing other than those listed and discussed here. These may include those insights induced under drugs, sickness, or brain-cell implant. This may overlap the private base. Overlapping is not uncommon throughout this analysis. Knowledge gained from “other” sources may be repeated or repeatable but only in a limited way.

Knowledge of presence or *place* (see below) is said to be gained in unusual ways, perhaps electromagnetism, as in migrating birds, or by some total, innate, multi-sensory comprehension of conditions, including impending attack and "imprinted" conditions of early childhood.

From a great knowledge base, a very-small constrained space, where “good” (or acceptable) may exist and may have been marked, leaving very few items or area as acceptable and believable, thus known as “not rejected.”

**“Genetic”** is seen as insects emerge; some exist as adults for a very short period, perhaps only a few days, yet they know what to eat, in what patterns to behave, how to reproduce, and how to avoid some predators. Other organisms, including people, have some innate knowledge transmitted within the genetic code. The more dependent an animal is upon its parents, upon learning, the less information, knowledge for life, seems imparted in the code. The need for community-forming, demonstrated within wolf packs and in cub behaviors, is intrinsic. "Not knowing" results in "selection against" large numbers of individuals.

**“Place”** may be an epistemological base. A squirrel is not startled into jumping when a leaf falls beside it. It knows its terrain and actors. It dodges hawks; it ignores leaves. Short-lived insects know their foods, their homes, and their roles, but these can be claimed to be from a genetic base. A wilderness traveler sleeps soundly; the tenderfoot awakes at any hoot, every scurry in the leaves, every fire-brand collapse, and every rock roll in the stream.

From biology, we gain an alternative concept of how animals know anything, and that is "imprinting." The duckling knows its parent. A duckling brought from an egg incubator imprints on a human child or adult and behaves toward it as it might to its parent. There is evidence that birds and insects also "imprint" on spaces and structure. They return to the same nesting area; they build the same nests; they use the same nest-size holes. Wood ducks, raised in boxes, return from migration to nest in boxes. Progeny of wasps, having built a paper nest on wires on the ground, return to the same wires. Migratory fish imprint on the chemical characteristics of their original streams.

Perhaps place is an element of “cover.” People who grow up in grasslands love the plains and express discomfort at living among mountains. "Mountain people" tolerate, and express *ad nauseam* the beauty of coastal living, but long to return to the mountains. They know their place; they feel uncomfortable out of it.

In 2014, a note from The Conservation Foundation included: "Have you ever walked through a field or hiked to the top of a steep mountain and felt intuitively connected to that place – to its history and to the people who have been there before you? This month as we celebrate the birth of America and our 238 years as a country..." They were relating, I hypothesize, with "place" and a special kind of connection.

Place is an ancillary type of the coherent epistemological base. Most bases seem related. I cannot decide whether recognizing and knowing the name of a person (or a plant) or not doing so is a place phenomenon. Maybe there is only simple correlation in such observations, but I think failing to recognize an otherwise well-known person because he or she was in a totally unexpected place suggests the mental action of searching among several ways to know anything.

I visited northeastern China in 1989 and *knew* the place that I visited. I felt at home in the forest, though everything else was different. The species were different than those I knew, but the families and genera of plants were similar. The farms were the same. I could relate easily; I was familiar with the total, the "surround," a spatial gestalt. I knew the place. I knew what to expect. I did not feel at risk. However, I suspected that I could never feel comfortable in Senegal. Everything seemed different. I could not predict what was behind each tree, beneath the river surface, or what had caused the disturbances on the ground surface.

A student of mine took me to the Rann of Kutch in northwestern India, a vast, frightful, coastal salt desert. He was at home there. He loved the whole place; he knew it well. Place may be a way to know.

The **“private”** base is from those people who claim to have had very personal, perhaps unrepeatable experiences. They know something but how they know is private to them. It is perfectly sufficient, but its source is unavailable to others. Metaphysical experiences (revelations) are one of the grounds of private knowledge. The person having knowledge asserts "I just know!" to the question of "how?" Such knowledge cannot be investigated. The knowledge held is almost un-discussable. As Bendall asserted: "The notion of *truth* presupposes the notion of inquiry."

A **“sensory”** base of epistemology is that of "seeing is believing,” a well-known phrase. Upon reflection, it is only true for the trained observer and then it is limited. The variation in courtroom testimony about what has been seen can be convincing that the base is limited. Training of behaviorists, scientists, and law enforcement officers is notable because a sensory base can be improved.

People learn to improve their sensory perception with eyeglasses, hearing aids, and microscopes, etc. Most of the technology of environmental sampling is designed to improve sensory perception of the ecosystem. The perfect observation cannot, however, overcome a bad sampling strategy or bad research design. A sensory epistemology is limited because of limited sensory ability, training, equipment, etc. It is also limited because of communication. An un-communicated or poorly-communicated observation is private knowledge.

A blindfolded person smelling burnt hair and touched with an ice cube will "know," erroneously, he has been burned! It is almost impossible to have a pure stimulus. The context of the stimulus provides its meaning. To “know” based on sensory perception requires knowing the context.

Perceptive rural observers of all types and ages seem to know what to observe. They have a structure, organization, or model as a means of assembling sensory perceptions and thus avoiding "noise." The entropy of information systems is essential to know, dangerous not knowing. Noise may cause people to observe the wrong thing or in the wrong way. The structure (or context), not the sensory experience, may be flawed.

The sensory apparatus itself may be too. Being hit in the head, a person might exclaim: "I saw a blinding light!" This could occur in the dark. Drugs produce altered states that either reduce or enhance senses (e.g., guard dogs search better when given certain drugs). Dreams are often so real that people report events that have never occurred, were never known, measured, or otherwise sensed to have really occurred.

**“Contextual”** is a base of knowledge from language, one based on continuing agreement among users of a language. We assume people know what we mean by "hard," "soft," "pain," or "wet." We may know what land "carrying capacity" (e.g., for a wild animal population) means because of the way it is consistently and usefully used in a given work. We have little basis for discussing “riparian” because the words used are weak, incomplete, and imprecise. The contextual epistemological base is weak because a process for agreeing on the language is usually lacking; the users change in knowledge and need for the words, and the words themselves are mere models, codes, a representation almost by definition and thus not sufficiently true.

The **“coherence”** base is knowledge that fits with the rest of knowledge. We know that water does not run up hill, and that the sun always rises. The bird digging a hole in the sand dune is not a woodpecker. I know that! It fits with everything else that I know. This base is strong because it is related to a large fund of knowledge, but it fails to be able to establish the truthfulness of that fund, only the level of agreement. "How did you know that instrument would work?" asks the student. "It just made sense that it would, based on size, shape, design, price, reputation of the company, and reported-prior-use of similar equipment." ("Reputation" is precisely related to coherence.) "How do you know your proposed technique will work?" asks the skeptic. "It has never been tried here before; I just know!" Not private knowledge (but possibly), this claim may be a display of the coherence base, or perhaps experiential or authority.

A large fund of accurate knowledge is key to the usefulness of this coherence concept. Starting at an arbitrary point, a garbage-pile called “knowledge” could be built. Starting is not arbitrary, however. Coherence overlaps strongly, as do other bases, with authority, contextual, and induction.

**“Pragmatism”** dominates agriculture, forestry, rangeland, fisheries and environmental fields. The epistemological test is whether something is useful or whether it works. It usually includes concepts of efficiency (high output per unit input) or effectiveness (high, specifically-stated, desired output per unit input or time). Knowledge exists if it works to aid in managing people and the environment.

How to define “it works” is a looming problem. What works for some people or during one period may not work for others or in a later period. "I know I shall not get sick after boiling and eating these old beans" may be a statement of high certainty today, highly satisfying, but deadly tomorrow.

Pragmatism may be sufficient in local situations, but does not accommodate events in the tails of the normal curve or sectors of a complex computer program. It cannot handle rapid change or the new relations that arise when a factor is added to a decision analysis, such as a player change made in a losing team game or chemical synergism experienced. In general, when pressed, the pragmatist must shift to another base.

**“Induction”** is the classical “scientific method.” Baconian, it flows from hypothesis through test to conclusion. The last stage, publication or presentation, is usually omitted, but it is essential as a feedback loop for review and correction. The knowledge base is a small system with a shared conclusion, a knowledge statement being the objective. This procedure is logical, flows well, and the evidence is that it works. Knowledge through induction is based on processing evidence to arrive at results, then a conclusion.

This base may fail because of the sensory nature of much evidence used. I interviewed many professors before leaving a university and asked what should be gained from a Ph.D. degree. The most memorable answer included two major things: (1) how to ask answerable questions, and (2) the nature of evidence. The latter is a major difficulty of the inductive approach to knowledge.

Equally difficult to resolve are infrequently occurring events (e.g., earthquakes) and some for which evidence cannot be gained due to moral or other reasons. For example, “What is inside the church cornerstone?” Knowledge must await the church destruction. Can a person recover from a bite of a rabid animal on the shoulder? Can a person get rabies by aspirating air from a cave with rabid bats? The answers await immoral experiments or dangerous accidents. Some experiments are too costly to perform; some systems are too sparse to study except in some weak manner (e.g., endangered species); some populations are so variable that no conceivable experimental design will produce a conclusion other than that more studies are needed. The mark of experience and education, the evolution of a coherent epistemology augmenting the inductive, is to see the general in the truly unique.

**“Correspondence,”** also called deduction, is the epistemological base of knowledge dependent on tests of reality that are usually made against standards. Often considered a process of reasoning from the general to the particular, it is the converse of induction which seeks general rules, premises, and descriptors. Languages and mathematics are model-building media and models are examples of general representations of knowledge. How well models represent reality is a qualitative aspect of this base. A picture or painting is true, faithful, or accurate to the degree it corresponds to that which it represents.

To perceive anything is to form a mental image of it. This is true for a sensory experience or some entirely mental activity, perhaps of some previously unseen relationship among agro-ecosystem components. Truth is an expression of the accuracy of the replica or model in the mind to the things outside of the mind. Every abstraction, every model, is, in part, a falsification because of what it omits.

Correspondence is an analysis of the truthfulness of the model. Not computer models, but communicated expressions of the model in the mind are the topic here. Without communication, the model is private. Correspondence becomes the major issue in deciding how well the results of questionnaires reflect reality, perception of scenery, willingness to pay for recreation, and importance of objectives. These are models, and how well they represent the human mind and the fundamental decision-making process remains an important question, a major dimension of deductive work.

Correspondence in human life may be seen in three dimensions. At any time, a person, enterprise, or agency may locate itself within a space among: (1) what they are doing, their life expression, (2) what they think and say they are, and (3) what they perceive they can become. The perception of what a person, group, organization, agency, etc. may become may itself be flawed, and may be either excessive (beyond any practical levels of attainment) or conservative. Resolution of these differences is in the literature of "human potential," of ethical behavior, of humanism, and, of course, theology as it may relate humans to their god-concept. Within psychology, the lack of correspondence among these concepts is discussed as "cognitive dissonance." In marketing, they are discussed in relation to what a buyer wants, needs, and feels he or she deserves.

How do we (anyone) know what's right or the best option? Anything? We can know well using the elements of epistemology. With each, we work toward answers provided within the framework (the context) of the elements, rates of change, timeliness, and perceived constraints… often assembled into models yielding answers with their probabilities and constraints. Defining "best" results is possible in a "ball-park" — "fences" of probability—within the constraints of linked criteria. (Computers are now ready to help with this analysis.) In Chapter 6, epistemological concepts are applied to Rural System's specific approach: rational robustness.

## Heuristic Convergence

Within Rural System we propose to do deductive and inductive studies, explore the full list of criteria for knowing anything, and advance **heuristic convergence** of the criteria or bases for knowing toward tentative approximations and a pragmatic paradigm.

The Studies Group will seek an alternative to "classical research" within diverse rural resources under extreme pressures. We have a point of view that classical research may not serve the field(s) of rural resource management well, or adequately. **Induction** is only one way of knowing or discovering anything; **deduction** is also available, but limited. Even together, as we investigate heuristic convergence of the criteria for knowing, they may not suffice.

"Heuristics" is not a widely-used word, but it is an exciting one, full of subtlety and potentially quite rich. It is not a scientific word for it is much too imprecise, but it carries information and has its own ambience. Roughly, it means the way one finds out or discovers. (*Heuristic*, for us, means *a discovering*, often personal—an experimental, trial-and-error, exploratory approach to problem solving.)

Each approach is limited. Barriers to study abound. Classical research or studies are characterized by singular hypotheses, tests of falsity or untruth, tightly-controlled experiments, conservative conclusions, and journal-based publications with limited reading and few rewards for implementing results. Costs of studies and findings go unreported. There *are* strong alternatives, and an active one is needed. There are many reasons... sensed by a few people, and alternatives emerge from among them. *Alternative* is an emphasis, not a *contest*.

### Reasons to Seek Alternatives to Classical Research

**Reason 1.** The scope of rural work is excessively large. Consider many animals, plants, ecosystems, history, endangerment, pest damage, operations research, economics, and all aspects of human behavior.

**Reason 2.** Simple, meaningful, stable hypotheses can rarely be formulated.

**Reason 3.** Classical research tests can rarely be made within a meaningful period. The lifespan of many animals; the lives of trees, shrubs, and vines; the changing nature of humans and their conditions over their life span; and the human alterations of land and environment away from sites being observed all deny the real possibility of "controlled" experiments.

**Reason 4.** The movements of animals prevent genuine controls. Islands and enclosures are used in some cases, and are stated as desired in others. The conditions of studies are *atypical*, but answers are desired from representative, *typical* situations.

**Reason 5.** Most research-based workers are employed by government agencies and moves are often made. Stability is rare. While 'control' over the environment might be made, appropriate control over observer differences can rarely be gained for long studies.

**Reason 6.** Even for short studies, control over observer differences for observing several *areas* or *periods* can rarely be gained.

**Reason 7.** There are too many topics to address to conceive of ever finishing an experimental effort. Even anticipating the long persistence of humans and the scientific community, expanded workers, efficiency, *and funds allocated*, the tasks ahead now seen seem unattainable. To act otherwise is irrational. The underlying premise of science is rationality. We approach awareness of limits and alternative needs. For example, consider the following questions and try making a rough guess or approximation for each question:

1. How many bird species are in your state, region, country, etc. (the area of concern)?
2. How many mammal species?
3. How many fish species?
4. How many aquatic mollusk species?
5. How many terrestrial pulmonates (land snails)?
6. How many crustacean species?
7. How many snake species?
8. How many lizard species?
9. How many turtle species?
10. How many salamander species?
11. How many toad and frog species?

Assuming the average citizen will estimate over 50 for each, there are thus 11 x 50 = over 550 species for realms of research questions and topics—animal species alone—and hundreds of questions are waiting about each species. There are thus probably thousands of species in our areas of interest, with a minimum of 50 questions on average yet to be answered about each species. Now consider the number of experiments or research projects remaining to address each question, even ignoring paired combinations of the above and the meaninglessly-large numbers of permutations of such live elements. There is a *very* large number of studies to be done, even during the remaining life period of many, very effective classical scientists.

**Reason 8.** The expertise to conduct the needed studies is not available and even under extreme assumptions about distribution, success per year, and educational system output of competent researchers, the numbers of experienced researchers likely to be needed will not be available.

**Reason 9.** The financial resources for classical research work are not likely to be available. In 2012 there were 6.2 million scientists and engineers in the United States. The average wage for scientists in 2012 was $87,330[4] per year, so the costs of the needed, basic species-specific knowledge are clearly *very* large. The likelihood of the field of rural and/or faunal systems management *ever* having such resources for designed work seems very low. To act as if they will become available soon, even for a region, state, or country, seems irrational.

**Reason 10.** The time is not available. Species are being lost daily; crises are commonplace. Interrupted studies are common. Even with new computer power, eventual mastery of a small, stable system is not a rational model for faunal system studies. Inductive, observational, descriptive studies of fauna and their related floral systems seem irrational and inappropriate for rural and faunal system managers.

There are 10 reasons listed for why alternative studies are needed. The alternative I advance within Rural System is developing a pragmatic paradigm, one of *heuristic convergence* toward tentative approximations. How would we recognize it? This pragmatic paradigm will eventually be seen to have the following characteristics and actions:

1. Clarifying the realm of work, answers will be sought only to pre-stated questions.
2. Being highly predictive, such as in: "If *this* action is taken, then *these* consequences can be expected..."
3. Starting with the end in mind. If truth seems available in a situation, to what use will it be put? Assuming a perfect study yields results, what are the related uses? Diversifying inquiry to studies that produce results likely to be broadly useful, such as knowledge of processes (e.g., erosion, metabolism, and trail-following behaviors).
4. Seeking knowledge likely relevant to several species.
5. Studying *a priori* universal factors that provide massive control in perceived variance, such as abiotic factors (solar radiation, precipitation, evapotranspiration) and their related forces.
6. Creating universal algorithms for computing point, line, area, and volume relations.
7. Building transition matrices (e.g., ecological succession) that allow for the use of GIS with predictions.
8. Giving special attention to functional taxonomy, naming individuals and groups related to currently-perceived human benefits rather than to anatomical characteristics.
9. Paying attention to life-group or stage (e.g., turkey poult vs. adult turkey). There are greater managerial differences in life groups within some species than between some families of organisms.
10. Conducting "expeditions" to gain economies of scale and interactions among professionals and amateurs, e.g., coordinated regional and state faunal and floral surveys.
11. Attending to specific units of benefit provided by the resource, e.g., organs, pelts, and sightings.
12. Measuring and reporting demand for the units perceived to be needed by nominal populations of people.

[4] Sargent Jr JF. The U.S. Science and Engineering Workforce: Recent, Current, and Projected Employment, Wages, and Unemployment. Congressional Research Service. Rep. no. R43061.

13. Analyzing substitutability—how one faunal or floral event, experience, or benefit unit may substitute for another.
14. Making non-linear cost estimates available for decision makers, the expected faunal and floral benefits produced per unit of expenditure over time.
15. Rejecting the strenuous pressure for parsimony in models: a retreat from calculus models to difference models.
16. Using GIS software in optimization, such as in selecting optimum power line, water corridors, and floral management units.
17. Using, with feedback, the opinions and knowledge of aged, experienced people, often in expert systems.
18. Selecting and using statistical alpha of about 0.20 rather than the often-used level of 0.05 (the 80% rather than 95% level of confidence).
19. Paying attention to equifinality, the principle of finding multiple, different pathways to the same end-state in a system.
20. Paying new attention and reporting the role of observed *sequences* within natural, outdoor, or rural sequenced observations (e.g., pre-post rain, high-wind, days since fire).
21. Dynamically developing prescriptive systems, computer-based, with reports or plans that are temporary and grounded in dynamic databases, optimization programs, and report generators. These will progressively depend less and less on paper or hard-copy texts, maps, and illustrations.
22. Forming new institutional arrangements to increase permanence and utility of knowledge gained at such high costs, and often great risk and hardship. These may include data storage systems, hypertext, expert interviews, and video image storage.
23. Using non-governmental strategies (e.g., public observation, social media) to assure stability of research programs and long-term, essential studies.
24. Developing a cadre of supportive retired scientists and practitioners with a grasp of the now-foreseen needs before 2050 AD.

Research modes are well-known. They have served well. Many successes can be attributed to doing science in "the old fashion way." Yet regrettably, it becomes clearer to some that the problems of the rural and faunal resource manager cannot be solved in ample time, given expected resources and international dynamics, and with the likely talents available, by using classical scientific models.

The brevity of the 6-step inductive process has had great appeal as well as success, but a clear pathway to the future is not seen. We seek an alternative. The need is for diligent searching, creativity and engagement of a rational strategy for gaining knowledge, the truth spaces for active use by future managers of rural and biological resources and their human benefits. People now need help from studies, produced knowledge for confronting and surviving the yet unimaginable stresses of the near future.

## A Heuristic Convergence Strategy

Key parts of heuristic convergence will be in the 11 classes of benefits (Chapter 2). Others are:

**Hope** – Strangely (at least to me) hope is no longer widely used, perhaps because it has excessive metaphysical connotations. Nevertheless, *hope* remains a good and useful word that includes concepts of both goals and expectations of their achievement. It states perceived desirability of X and a level of intensity of that desire, and is a statement about the pathways to that future instant when X begins.

**Nascent Theory** – Work needed is on what might be expected and on written reason, not just summaries of "more-than-30" observations, mere chance notes grasped from a tornadic data-machine. “What makes sense?” is the question as well as the *demand* from serious theory today. Stop collecting data! Theorize! The proposed theory’s *causative* may be true, even if not supported by the data yet. Within Rural System, we live based on the best available theory, processed, not the data. There is no more time for peripatetic moves through a jungle of ideas and experiences. Theorize!

**The Basic-Applied Dichotomy** – It is easy to understand and appreciate administrative, budgetary, and legalistic reasons why there needs to be taxonomic separation between basic and applied research. Only recently has it become evident how harmful that taxonomy has been to science. We know it exists, multidimensional but continuous. The fundamental difference between basic and applied is that of *when* the conclusions reached are applied. Basic research seems to take longer for its findings to be applied, a trivial distinction on a temporal continuum. Taxonomic and administrative problems arise when basic research is quickly applied, and so-called applied research findings languish in the shade.

There is no longer any meaningful difference between these taxa; they are artificial, and are intellectually, personally, and organizationally divisive. They are the roots of great ineffectiveness in the scientific community—especially those dealing with land-use questions. By focusing in the future on wholeness, similarity, and generality, predictions will be more correctly made. There is only one science.

**Sequences** – It seems conspicuous when looked at directly that a major aspect of the research application-rate problem is the problem of the sequence of discovery. Perhaps it is obvious, but emphasis is needed to prevent losing sight of the sequence phenomenon in research and to avoid attributing more to the basic-applied dichotomy than it deserves. The apparent scientific successes are those that, by chance or planning, fall in a fortuitous sequence. The fate of absolutely equal quality research (by any criterion) is a function of the environment in which the results are placed.

The analogy of a three-number lock combination is somewhat instructive. Three correct numbers will not allow entrance, only numbers *and* the proper *sequence*. The odds of the proper sequence are quite low. Ackoff (1962)[5] delineated *sequential* and *simultaneous* research strategies and their counter-balancing forces of costs, time, and risks. Sequential research has lower costs, takes longer, but involves less risk than simultaneous research. Simultaneous research is a broad, multi-worker, multi-lab approach usually taken in a short period.

I’m convinced that the scientific community has little time (i.e., until 2050 AD and world population abundance and food and water supply shortages collide) to aid people significantly

[5] Ackoff RL. 1962. Scientific method: optimizing applied research decisions. New York (NY): John Wiley and Sons, Inc.

and to preserve current living standards (at least for U.S. citizens). Only simultaneous assaults on major research issues such as land use seem appropriate. My conviction arises from observations of a host of environmental problems, the increase in counterintuitive consequences of many of the most altruistic actions, and the rate at which thresholds of tolerance and supply are reached.

Although I advocate simultaneous research—team assaults on major problems—in such projects there are likely inefficiencies and partial failures. Nevertheless, such projects seem advantageous because they buy society time. They quickly put conclusions and discoveries into the hands of decision-makers and shapers of society. Yet, there exists today a socio-political order that appears unwilling to tolerate costly, simultaneous research programs. The programs are needed, desperately, but they seem unlikely. Society will trade time for risk and time for cost. Instead of buying time, society spends it. This is very saddening; it is a decision that can be reversed, but it does not seem likely. Sequential research therefore is most likely to be done because of cost constraints, and because of the **social ignorance** that says (1) we have unlimited time, and (2) the burgeoning multi-country society with its demands is not at great risk.

The only current hope that can counter this failure is in independent, localized, small-scale research planning. Since sequential research seems inevitable, planning can reduce its costs, and importantly, allow all possible haste.

Research planning has been advocated for years. Its need is voiced again, but perhaps in more meaningful terms than the past. The planning needs are for solving problems like: (1) How can people maximize the total costs of delivering minimum, adequate in-dish meals to a person of specified sex, age, and weight anywhere in the world? (2) How can people achieve a sure, high-quality groundwater resource for all the people of the U.S. and Earth by 2030 AD? (3) How can people preserve, for use, the present gene pool in wild and domestic animals? (4) How, for example, can people plan and shape 200,000 hectares for optimal biotic production for 1,000 years?

These are problem questions appropriate for high science. They are timely, researchable, essential, and will require assiduous application of the scientific method, from the most esoteric and micro to the most philosophical and macro approaches. They cannot be achieved in any period of time that has relevance to the human condition without the most profound and scholarly thought, without at least one or more people thinking them all the way through and writing or diagramming their thoughts. Previously there was not enough known, or the technology was unavailable to do so; these conditions have changed. The plan that will result following such thought must exist; it must be charted, it must be a shared view, it must be begun, and it must be altered as need arises. With all this, the goal must remain, and pressure and leadership must be exercised to achieve the goal.

Of course, every scientist does not have to "join up" with a single simultaneous research program; there can be enough programs to occupy all scientists and require more. There need to be "outliers"—challengers—those with the viable alternate hypotheses, and they should be supported. There are enough parallels in biology to be convincing that long-term survival is closely tied to energy spent on monitoring, dispersing, and diversifying, and that society needs to fund these mutant efforts. But there must be a plan; the risk of planning must be assumed, as the only alternative to the risk of no planning.

Every study must have, at least, a well-planned home site. Research planning advocated herein has no similarity to the typical agency document called a research plan, little more than an open palm to Congress. More meetings held by planners will offer few aids. Neither will glorified statistical services or platitudinous reports offer much aid.

Planning involves seeing where we as a world society, as a nation, must be before 2050 AD, charting a minimum course to that destination, and creating decision aids to allow changes along the way to a clear end. Planners can say: "At least we must know B or at least we must have greater precision in our estimates of rate Q." This is possible in land use; it is probably possible for most of science.

**Occurrence –** Dr. Byron Cooper, the late dean of Appalachian geologists, once showed me a giant community water tank placed on a rock outcrop, and told me with unusual confidence that the particular rock *would* fail and the tank be destroyed—but he could not tell *when.* The people below it lived in ignorance. Thousands of people live on flood plains, fully aware of flooding, willing to do so with knowledge of high waters. They do not live in ignorance, only with uncertainty about when floods will occur. There are dozens of similar examples of mixed personal and social calculus, and Starr (1969)[6] suggested that people make conceptual third-power transformations when dealing with risk, i.e., they are prone to equate hazards to the third power of the benefits, real or imagined.

Society has not sorted out these complexities. It probably operates intellectually in a linear domain where the worst imaginable risk is loss of a member of the family. This socio-intellectual state neither justifies nor excuses scientists' snipes at those who create models and cannot match temporal events very well. I think that while risk taking can be investigated, it is ascientific. It is a human trait, a function of a historic, physiological, psychological, sociological, theological, and economic milieu. It cannot be observed directly, only behaviorally. Its expression in behavior can be manipulated.

There is no way to avoid a risky world; certainty of uncertainty is one of the “immutable laws” with which people must live. Thus, like assigning weights or expressing preference, assigning acceptable risk levels is a human act and at least for the purpose of this analysis, ascientific.

There are scientific laws, and these form the basis for a belief that occurrence of a class of things can be predicted with near certainty. I view estimating flood rates as a scientific activity, just as I do predicting weather events and the occurrence of solar and planetary events. These are activities dealing with occurrence and at least somewhat with temporal precision and magnitude.

The precise details of the future are not needed, even if it is possible to know them. Instead, what are needed are general characteristics of the future, expressions of orders of magnitude, and the near-presence of thresholds of concern. As Starr and Rudman (1973)[7] said in a parallel vein for land use: "While it is obviously not possible to predict the content and time scale of specific technical achievements which may be important in future social change, it may be feasible to see the *range* of the general characteristics of growth of that societal resource encompassed by the common term ‘technology.’"

Similar negative comments have been made about biologists' inability to predict micro-events about wild fauna models. Could the formation of an anti-hunter group have been predicted when law Q was modified? It could have. At least the option could have been explored, and strategies then developed for dealing with occurrences of high probability. Whether it would occur in a particular area at a particular time or with a particular intensity of feeling implies the existence of more knowledge than is available for even some of the better-known aspects of science. Such knowledge is not achievable at present rates of acquisition, with present

[6] Starr C. 1969. Social benefit versus technological growth. Science. 165:1232-1238.
[7] Starr C, Rudman R. 1973. Parameters of technological growth. Science. 182:358-364.

organizations, or at current funding over any reasonable future period, say the next 500 to 1,000 years. It is unreasonable to continue to behave as if it could be achieved. Rural System's rationally robust strategy (Chapter 6) is a viable alternative.

Returning to the problem of **sequence** above, the forester is well attuned to the site that is "perfect" for one species but is stocked with another. A timber stand exists if a seed-source was present, if a fire occurred after seeding, if the ground conditions were right for the seed, and if the rain fell before or after the fire. A stand is a function of *sequence* as much as *factor*. The forest scientist with complete knowledge (in the theoretical sense) of all forest factors cannot predict, *a priori*, a forest stand because of the innumerable sequences. Yet foresters can predict a forest will occur, and over time what kind of forest will eventually exist.

Limited knowledge is not discouraging; it allows the forester to explain what he or she sees, and to compute with various degrees of probability the future states of the forest on any land. People desire certainty; it does not exist. Even limited awareness from studies allows people to operate with less entropy or frustration, more attuned to the probabilistic world.

**Duration –** The expanding "confidence bounds" on regression analyses, examining the strengths of trends and patterns in data, are familiar. The farther into the future one projects, the less confident one tends to become. But prediction is not projection and the statement about increasing confidence bounds does not necessarily apply, especially if attention is given to the occurrence phenomenon above.

An example in resource use may be instructive. Elk forage following fire or clear cutting is known to follow certain rules of succession (*sequence above)*—being irruptive, and then declining to a fairly constant state over time (about 50 years). There are difficulties in predicting forage in the first 10 years (the confidence bounds are quite wide), but the problem becomes easier later. Aggregating these production functions can yield a far truer picture of regional elk forage in the distant future than the near future.

To understand land use change, and to predict it, one must understand succession.[8] Further advances in this area have been made (Chapter 4), and are sufficient to allow scientists to estimate now the long-term consequences of almost any act, such as those resulting from a spill of toxic material, construction of a power line, or building an airport.[9]

The interaction between **sequence** and **duration** is fraught with challenges. A host of degenerating, poorly-made decisions of the past still beset present society. Large dams, contaminated areas, exterminated species, and desert range overgrazing are examples. These are irrevocable. Their rate of occurrence has probably slowed, but it is still a positive rate.

Students once worked with my computer game, called Waterloo, trying to stabilize the shrimp in a coastal estuary. The shrimp are a biological integrator of most of the factors of the watershed. Only late in the game did they usually realize that they could not replace the silt lost to beach erosion by their watershed decisions. The replacement silt from the watershed is all trapped behind a dam that was built prior to their involvement and a part of the game. They were saddened and frustrated by this discovery. The best of managerial knowledge—perfection, if it exists—cannot overcome the constraints placed on their system by past generations.

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[8] Golley FB. 1977. Ecological succession. In: Benchmark Papers in Ecology, Vol. 5. Stroudsburg (PA): Dowden, Hutchinson and Ross, Inc.

[9] Giles Jr RH, Snyder N. 1970. Simulation techniques in wildlife habitat management. In: Bailey JA, Elder W, McKinney TD, editors. 1974. Readings in wildlife conservation. Washington (DC): The Wildlife Society. p. 637-654.

**Retrospect –** Lest there be confusion, a review may be useful at this point. Herein, the pathways have been analyzed to discover the role that science has in predicting futures. To this point a unified humanistic concept of science has been presented. 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 that society is likely to opt for more sequential than simultaneous research.

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 ken 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. The limitations have been discussed under interactive topics of sequence, occurrence, and duration.

**The Problems of Space –** There are scant research papers that provide the latitude, longitude, and elevation where studies were conducted. So many phenomena operate in this real, three-dimensional space (e.g., electromagnetism, insolation, gravity fields) that additional controls may be gained on the variance that typically is observed. Besides this subtle point, it is possible to begin to focus on site-specific prediction.

Each point or cell on the Earth may be characterized in hundreds of ways. Computers are now capable of storing and retrieving these data and putting them together in the best ways currently known. These are the intricate relations of any site. A new scientific orientation to each multi-dimensional Earth spot can produce huge gains in predictive capabilities. There is no way to visit each cell in Virginia for research (to do so even for one hour each would take over 60 working years). Idaho has 2.1 times the area of Virginia; there are a few states in between. Scientists have classified and clumped data in the past to an amazing degree. There are regions and range maps of all types; “lumpers and splitters” take on new meanings.

The spatial domain is not unrestricted. Certain life forms have altitudinal limits. These can be used to eliminate the grossness and unpredictability of many animal and plant range maps. Predictability can be improved by managerially restricting certain areas from use. Land use zoning by people is somewhat related. A new zoning based on prediction is possible. Because we know that certain plants will undergo moisture stress in their lifetime if planted in cell of coordinate x, y, z, then let managers be sure that they are willing to assume the risk of that loss (or pay the total long term costs). Let society be sure pesticide use will not be required in a map-cell when that cell is near another one in which occurs a highly-threatened life form. By such action and containment, it is possible to reduce the mismatches in predictions and reduce the large number of alternatives that must be explored in struggles to see the future.

If site visits to the land are impossible in real time, Landsat 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. 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. No scientist, having carefully computed sample sizes, will add excess animals to experiments. No nation can afford unlimited or excessive research projects; the value of **n**, the sample size, must be carefully computed. Attention must be given to holistic computer models, particularly simulations that allow planners and managers to ask "what if...?" questions assuming goal sets as well as action proposed on the land. When equations are not known, then subjective probability needs to be used, computing using the best current knowledge in a system with abundant feedback over time.

**The Energy-Matter Problems –** Not enough effort has been spent on the net energetics of systems. Adopting an energy metric provides an invaluable aid to modeling.[10] Integrating various researchers' work and making tradeoffs and comparisons between quite different concepts can be expedited among these who adopt the metric and become attuned more closely to energy transfer and its loss relations in many systems.

**The Variety Problem –** Variety is a general word for variance, juxtaposition, richness, various aggregation indices, and diversity. It is interactive with the above topics. Knowledge of it adds another dimension, and thus increases the potential to predict and control temporal as well as spatial occurrence. It allows such concepts as **likely yield** and **site quality** to be quantified.

Modern science tends to be probabilistic, and thus is rooted in population theory. Variety or variance is a population characteristic. Inductive science has a role in predicting the future of *population.* There is little it can do for the absolutely unique event. It is far easier to remember that ecosystems are unique than that animals are unique. This premise needs careful handling for it can be misleading. In the same way that every person is said to be unique, every animal is also. Every geographic cell on the Earth's surface is different, by at least one characteristic. Classical experimental procedures generally assume internal similarity and work to achieve control over external variables. Such abundant computer data storage is now available that aggregation into statistics may not be necessary. Individual plants, animals, and ecosystems—even humans—may be allowed to retain their identity and uniqueness in a large matrix. They are assigned a place in a sequenced, scaled, n-dimensional topology. The observed individuals occupy space in a hypervolume.

**The Resource Tetrahedron –** To this point, the four major aspects of any natural resource have been developed.[11] They can be depicted as being at the four interactive vertices of a tetrahedron. By seeing energy (and/or matter) as having associated weights, risks, and desired or expected quantities (valued energy), the tetrahedron unifies the salient, stable dimensions of all natural resource and land use issues. The tetrahedron is discovered to be a means for bringing, symbolically at least, order and unification to the chaos of the resource and land use issue. From such organization and clarification people may gain additional hope. The role of scientific inquiry is to develop these mathematics, revise the statistics, and continually unify knowledge.

There is a fundamental epistemological question behind stating the role of anything. How do I know? The scientific method is said to include description, explanation, and prediction. The former two are means to the latter. The entire scientific enterprise can be viewed as being focused on prediction, in explaining the past, for the future is likely to function similarly. Clearly the future will not be like the past, but it will *function* like the past. It is in the understanding of these functional relations, used in synthetic models with high deductive skills, that the future can be known, that consequences of acts can be evaluated before they are performed, and that the future world can then be shaped as a proper place for humankind.

[10] Odum EP, Odum EC. 1976. Energy basis for man and nature. New York (NY: McGraw-Hill Book Co.
[11] Watt KEF. 1973. Principles of environmental science. New York (NY): McGraw-Hill Book Co.

# 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.

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