Beaver, Bluestem, and Bluegrass: Human Health and the Changing Ecology of the Des Moines River Watershed

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"It isn't what we don't know that gives us trouble, it's what we know that ain't so."—Will Rogers

There are four things I would like to cover: a look at a very specific bio-region in Iowa, with focus on the environment and related health issues; a look at Iowa's past and how we got from there to our current situation; a quick survey of a modern, healthy environmental system; and finally, some speculation on what the implications of these environmental systems, past and present, might be for health today. Before I move into those issues, I would like to present briefly the scientific framework that I use to study these areas.

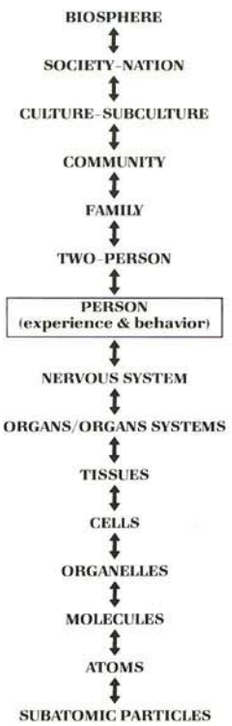
Figure 1 is taken from Engel.[1] It depicts a hierarchical system starting with subatomic particles at the bottom and moving up through larger and larger systems, until we encounter the person, the two person or dyad, families, communities, etc. Expanding on this concept, we can envision an even better hierarchy in which all of the systems are incorporated into ever enlarging systems. Or, if you like, you can have a reverse "hierarchy" with the smallest on the outside, thus, perhaps, moving it into mysticism or the spiritual realm; but that is sometimes important, too. Anyhow, when we speak of systems in family medicine we are almost always referring to family systems; but as you can see, there are numerous other systems. As generalists, all of these systems are relevant to our concerns.

Systems Thinking

Weinberg[2] has written a delightful book called *An Introduction to General Systems Thinking*. Weinberg is a systems engineer and much of what's relevant in systems is relevant to all types of systems. In the diagram from Weinberg, (Figure 2) he graphs on the horizontal axis complexity or number of subjects. On the vertical axis is increased diversity or randomness. Weinberg says that only in area I in the corner of the graph where there are relatively small numbers of subjects and relatively uncomplex systems, is analytical, classical, or the reductionist science of Newton the appropriate scientific approach. In area II, where there are large complex systems, the statistical treatment or the approach of epidemiologists is the appropriate scientific approach. But in area III, which he diagrammed as a fairly large area including whole persons, families, and communities, neither of these approaches works very well. It is in this area that systems thinking is of most use to us.

Prigogine[3] and his colleagues in Europe have recently published a book in the U.S., *Order Out of Chaos: Man's Dialogue With Nature*. It's been in publication in Europe since 1979. It is a difficult book. It goes through the history of science, and physics in particular. There are many things in Prigogine's book that shake the very foundations of science as we know it. To paraphrase one small example that is particularly relevant: As systems move further and further from equilibrium (most systems actually operate somewhere in this realm) there is always change going on. Very seldom is a system actually in equilibrium. And, if it moves far enough from equilibrium into a position labeled "far from equilibrium," something happens that is

Figure 1
HIERARCHY OF NATURAL SYSTEMS
(Levels of Organization)



Engle, G.L. "The Clinical Application of the Biopsychosocial Model," *The American Journal of Psychiatry*, May, 1980; 137:535-544.

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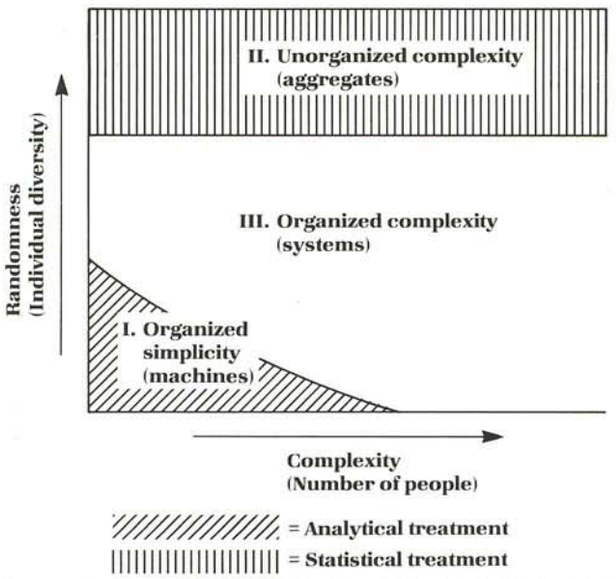
totally unpredictable: the system reorganizes. Prigogine developed his theory from fluid dynamics and what happens to water as you heat it. As water goes farther and farther from equilibrium it reaches a point where it begins to boil and the molecules reorganize themselves into hexagonal configurations. He says that reorganization happens to all systems as they get farther and farther from equilibrium. How they reorganize is unpredictable.

Figure 3 is a description of the differences between the rationalistic paradigm and the naturalistic paradigm. The rationalistic paradigm is the one of which the biomedical sciences are an offspring; the naturalistic paradigm is one that is useful for the study of systems. There is a lot of work that needs to be done in the naturalistic approach to observation and studying systems. One of the key questions is how the trustworthiness of naturalistic inquiry is assessed. Guba[4] (Figure 4) lists different approaches to assessing the trustworthiness of naturalistic inquiry.

Figure 2

Types of systems with respect to methods of thinking.



Naturalistic Inquiry

With this background I would like to present a naturalistic inquiry, without theory but guided by general systems thinking, into the very specific relationships between human health and the ecology of the Des Moines River watershed.

The Des Moines watershed crosses into three different states, with Minnesota and Missouri to the north and south of Iowa. Picture 1 is the Saylorville Reservoir. The nice thing about approaching a concern from a systems perspective is that everything is related to everything else. This scene is half a mile from my front door and a place where I often walk. It's one of the many large U.S. Army Corps of Engineers lakes that have sprouted up throughout the country. At first glance, it appears to be a pleasant, healthy place. On closer inspection, as is

(Picture 1)

almost always the case, the systems aren't always as healthy as they first appear. There is often floodwater and various types of floating debris. The floodwater, of course, comes from the entire watershed and accumulates in the Saylorville Reservoir. To get a good idea of what's occurring, it is necessary to travel up the watershed, up the small streams to a plowed field.

The plowed field is the reason the water flows off the watershed so quickly that the reservoir was built to protect the downstream cities, particularly Des Moines, from flooding. The plowing and subsequent rapid runoff is also the reason Louisiana owns almost as much of Iowa as Iowa owns. It is estimated that roughly one-half of the topsoil of Iowa, soil that took ten thousand years to accumulate, has disappeared down the watershed in the last 100 years.

There is a reason, of course, for all this plowing. It is to raise the products that make Iowa a rich farming state, particularly corn and soybeans. These crops go mainly to feed livestock. In the industrial system of agriculture, which Iowa has embraced in the last couple of decades, it takes

Figure 3

AXIOMATIC DIFFERENCES BETWEEN THE RATIONALISTIC AND NATURALISTIC PARADIGMS[4]

Axioms About	*Rationalistic Paradigm*	*Naturalistic Paradigm*
Reality	Single, tangible convergent, fragmentable	Multiple, intangible divergent, holistic
Inquirer/Respondent relationship	Independent	Inter-related
Nature of truth statements	Context-free generalizations — nomothetic statements — focus on similarities	Context-bound working hypotheses — idiographic statements — focus on differences
Attribution/explanation of action	Real causes; temporally precedent or simultaneous; manipulable; probabilistic.	Attributional shapers; interactive (feed-forward and feed-back); non-manipulable; plausible.
Relation to values to inquiry	Value-free	Value-bound

Figure 4

THE TRUSTWORTHINESS OF NATURALISTIC INQUIRY

- **I. CREDIBILITY**
  - **A. Prolonged engagement at a site**
  - **B. Persistent observation**
  - **C. Peers debriefing**
  - **D. Triangulation**
  - **E. Referential adequacy materials**
  - **F. Member checks**
- **II. TRANSFERABILITY**
  - **A. Theoretical/Purposive sampling**
  - **B. Thick description**
- **III. DEPENDABILITY**
  - **A. Use of overlap methods**
  - **B. Stepwise replication**
  - **C. The dependability audit**
- **IV. CONFIRMABILITY**
  - **A. Triangulation**
  - **B. Practicing reflexivity**
  - **C. The confirmability audit**

seven pounds of grain to produce one pound of beef. This demonstrates, perhaps, that while we think of industrial systems as being examples of great efficiency, they are probably best at maximizing profits.

Table 1 shows Polk County, Iowa death rates per thousand. Heart disease and neoplasms are roughly 50% again as prevalent in Iowa as nationally. Heart disease is, in part, related to consumption of meat high in saturated fats, and the agricultural system at which we have been looking produces meats high in saturated fats for human consumption.

Other Implications

There are a lot of other health implications in the farm system of modern Iowa, too. In April and May 1984, for instance, the Polk County Health Department issued a warning not to use water from the water system to feed infants because of high nitrate levels. These, too, are a legacy of the agricultural systems. The consumptive kind of agriculture in which Iowa has been engaged for the last several decades is related to the loss of soil; and the only way that productivity has been maintained is by augmenting the soil with billions and billions of tons of nitrogen fertilizer (not to mention herbicides and pesticides).

Table 1

TEN LEADING CAUSES OF DEATH IN POLK COUNTY

	Polk County		*National 1980*	
	Number	*Rate (per) 1,000*	*Number*	*Rate*
Heart disease	**925**	**301.3**	**761,085**	**202.0**
Malignant neoplasms (Cancer)	**559**	**182.1**	**416,509**	**132.8**
Cerebrovascular disease	**157**	**51.1**	**170,225**	**40.8**
All accidents	**86**	**28.0**	**105,718**	**42.3**
Influenza and pneumonia	**79**	**25.7**	**54,619**	**12.9**
Suicides	**46**	**15.0**	**26,869**	**11.4**
Other diseases of arteries, arterioles, and capillaries	**35**	**11.4**	**NA**	**NA**
Diabetes mellitus	**34**	**11.1**	**34,851**	**10.1**
Arteriosclerosis	**27**	**8.8**	**29.449**	**5.7**
Certain conditions originating in the perinatal period	**22**	**7.3**	**22,866**	**NA**

Source: Polk County figures, State Department of Health 1982 Resident Date list; national figures, National Center for Health Statistics Monthly Vital Statistics Report, 1980, printed Aug. 11, 1983.

Looking again at Table 1, the second most common cause of death in the county is cancer. This invites affiliation with agriculture. Consider:

- This spring there was a survey of local grain storage bins. Forty-eight bins were surveyed. All had EDB, a carcinogen, present. EDB has been banned as a grain fumigant for several years, and nobody can explain why those bins all still have EDB in them.
- In August 1984, we received another warning from our Des Moines waterworks saying that the level of TCE (trichloroethylene) in the water system had gone over 200 parts per billion. There are no standards for TCE; however, the U.S. Environmental Protection Agency recommends that water not be consumed if it has greater than 75 parts per billion.
- It is becoming widely known that leukemia, lymphoma, and multiple myeloma are significantly higher in counties with high corn production. The reason for this is not known but it is also apparent that the counties that have the highest level of pesticide and herbicide use are also the counties with the highest incidence of leukemia, lymphoma, and multiple myeloma among farmers.

Finally, we move to infectious illnesses. In 1984, Holmberg[5] reported 18 cases of Salmonella newport, all of which were multiply resistant to antibiotics. The cases were scattered all over Minnesota, South Dakota, Nebraska, Iowa, and Wisconsin. With one of those inspiring pieces of detective work by a whole crew from CDC in Atlanta, the source of the salmonella was traced — by a very complex process of identifying the exact plasmid characteristics of the bacteria — to meat from a specific feedlot in South Dakota. Furthermore, it developed that 12 of the 18 who had eaten the meat and developed the salmonella had all taken antibiotics, often self-prescribed, for some minor type of problem before coming down with typhoid. The speculation is that the normal flora was suppressed by the use of the antibiotics. The salmonella already present was then able to overgrow and produce illness. The *Des Moines Register*[6] reported that both the pharmaceutical and agricultural industries are now saying that the data is not accurate and that there are problems with the CDC study.

Fifty percent of all antibiotics used in this nation are fed to animals. The reason is curious; it is not for treatment of diseases, but to increase growth. Feeding antibiotics to animals accelerates their growth rate, for unknown reasons.

Cultural Impact

So far, we have discussed some fairly straightforward medical types of illnesses. But there is another whole realm of illness brought about by the industrialization of agriculture in America. The impact of this illness on the culture, the family, and the community is very difficult to address for a

clinician, and I might better refer you to Wendall Berry,[7] a farmer-poet from Kentucky. He is probably most noted for his book, *The Unsettling of America; Culture and Agriculture,* in which he describes in great depth what has happened to American culture as its agriculture has become increasingly industrialized.

Berry says, "Only if we know how the land was can we tell how it is." The tall grass prairie does not exist in Iowa any longer. Big bluestem is perhaps the most spectacular of all the prairie grasses. It was said that during the summer, at the height of the growing season, a man on horseback could barely see above the sea of grass. The reason that the vanished prairie is so relevant to modern Iowa is that the prairie grasses are what made the fertile soil of Iowa. For ten thousand years (roughly the time from the last ice age) the prairie plants went through an annual cycle of growth, death, and rebirth and over the ages developed the most fertile soil on all the earth.

Native Americans in Iowa lived along the stream beds because they were sheltered and protected by the forest that grew there. What more, appropriately, did they grow but corn and beans? They also grew squash, and I have not yet figured out why squash has not been one of Iowa's great products.

Somewhere around 200 to 300 years ago there was another major and very dramatic change that occurred, the beginning of the settling of Iowa by the European pioneers. The pioneers also grew corn and beans, which they had learned from the native Americans. But the pioneers also brought with them two things that probably changed Iowa forever. One was the plow and the other was the cow.

In the early days the settlers, mostly from Eastern hardwood forests, didn't homestead on the prairies. They considered them forbidding territories, as well as infertile. In 1833 a man named John Lane found that if he put a metal tip on the wood plow, the prairie could be broken more easily. And, in 1837 John Deere began importing rolled steel from England and producing steel plows. Within a period of two or three decades, the prairie all but disappeared. It is said that as the plow went through the virgin prairie, the sound of the root systems tearing and ripping was like the sound of a great battle.

Prairie and Pasture

The cow plays a role in the destruction of the prairie in a fascinating way. There were many grazing animals on the prairies. But the cow was different because the cow was always confined to a pasture, and the intense grazing over a period of decades led to the appearance of bluegrass and the decline of prairie grasses. Bluegrass grows from small nodules under the ground and these rhizomes will continue to grow and put out more sprigs of bluegrass. Cut the bluegrass off, by grazing for instance, and it will continue to grow. A prairie grass like bluestem, on the other hand, grows from nodules on the stem. If you cut off the bluestem (or most other prairie plants) at any point between these nodules, it will not grow any further that season, though it will come back next year because

(Picture 2)

it is a perennial plant. So, the cow had a very dramatic impact on the prairie because it produced an ecological shift that allowed bluegrass to become more prominent and bluestem to all but disappear.

I would like to use the beaver and the system that the beaver has established as an example of what healthy systems encompass. Picture 2 shows us a couple of things. One is diversity. At one time this was bare clay ground with nothing on it. The beavers dammed the stream and the willows began to grow. Once the willows became established the cottonwoods came. When these appeared, many other species of animals and plants began to appear, including over 30 species of Iowa birds that breed in this area, several species of mammals, and countless insects and plants.

Diversity is one of the cardinal characteristics of a healthy system. The beaver also shows a very good example of regeneration, which is another sign of a healthy system. The beavers have literally regenerated this entire area.

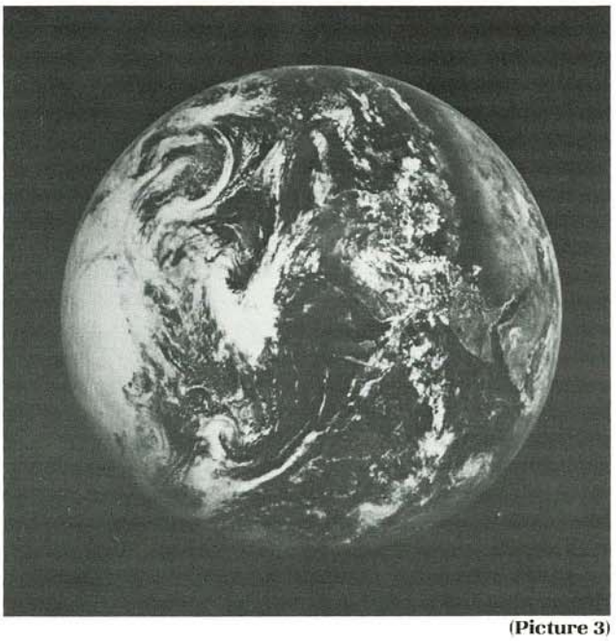
Another sign of a healthy system is perseverance. It might also be expressed as continuity. I don't know how long it takes for beavers to sit on their haunches and fell a tree two feet in diameter; however long, you get some sense of perseverance.

Another characteristic of healthy systems is response to local situations. Beavers are famous for canals, and it is one way beavers respond to local needs. One canal near the pond goes through a clump of willows. The beavers aren't very interested in willows. On the other end of the canal, however, is a grove of cottonwoods and the beaver savors the cottonwood much more than he does the willow.

One of the things that I find interesting about natural systems such as the healthy system of the beaver, is that there are no medically indigent. Every individual, every species has its place. Every species takes from the system but also contributes to the system.

Violence is part and parcel of the natural system. It may also be part and parcel of human systems. However, I believe that of all the species on earth, the human species does have the capability to rise above violence as a way of sustaining life.

I use the opening quote from Will Rogers to remind myself that a lot of what we "know" is just speculation. In this vein I now depart from my naturalistic observations of my local system and beginning to draw some speculative conclusions.



(Picture 3)

The "Whole-Earth" System

If there ever was a picture that changed the course of human history, it was Picture 3. For the first time it drove home the realization that the earth is a living organism. James Lovelock,[8] the British scientist, has written a book called *The Gay Hypothesis* in which he presents a picture of the earth as a living organism complete with cybernetic feedback systems. He bases this upon a vast series of observations. One is the content of the atmospheric gases. From what we have learned from our planetary exploration, the content of the gases of Earth, particularly the high content of oxygen, is most improbable. Lovelock says that this is because the Earth is actively engaged in regulating its own atmosphere so that it is compatible with life as it has developed. He draws the same conclusion from the salinity of the sea. Everything we know about erosion and the changes that occur between rainfall and the waters going into the sea suggest the saline content of the sea should be far greater than it is today. Again Lovelock says that this is because the Earth as a complete organism is involved in an active process of maintaining the salinity of the sea at a level that is compatible with life as it has developed on Earth.

When we look at modern Iowa, as we have today, it shows that we have lost the sense, the essential truth, that we are one with each other and all the Earth. This to me is the essential message of systems thinking.

I'd like now to return to coronary artery disease. Table 2 is from a 1984 report in *JAMA* concerning a group of individuals treated with cholestyrimine to lower cholesterol, and another group treated with a placebo. The treated group showed a fairly dramatic reduction in deaths due to coronary artery disease. But an interesting finding, not much discussed in the paper, was the fact that the total death rate between the two groups does not actually differ by very much. The reason for this was the increase in violent deaths in the treated group. There was one homicide, two suicides, and several deaths due to automobile accidents in which alcohol was probably part of the causal factor. The authors passed over it as a statistical quirk. However, in a 1981 *Lancet* article,[10] Oliver looked at three large studies of cholesterol lowering. In each of these studies the investigators looked at nonfatal infarction and found it reduced: 66%, 58%, & 25%; but noncardiovascular mortality increased 21%, 12%, & 32%. What the authors of the *JAMA* article suggested was a statistical quirk seems to be a fairly consistent finding in studies of cholestrol-lowering treatments plans. The *Lancet* author speculated that the reason for this had something to do with increasing the possibilities of cancer.

I think there is possibly another explanation that involves systems thinking. When a species is fortunate enough to develop an attribute that makes it more likely to succeed in its environment —an opposable thumb in the human species, for instance—the species generally becomes more successful. Almost always the specie's success can be measured by an increase in population. Under the impact of this increase different things can happen. One possibility is that the population can continue to increase. Another is that some type of limitation will develop externally that will limit the success of the species. (For example, in wildlife population biology, as the species becomes more and more successful it may be limited by the coevolution of a predator.) Species can also limit their population growth by internal factors such as limitation on reproductive productivity. As a species becomes more successful, it sometimes happens, for reasons not totally understood, that its birth rate begins to decline. (Of course in the human species we could do these things voluntarily.) If neither one of these events occurs, and the species continues to reproduce and continues to be successful, something else begins to happen—and this is universal. The environment begins to deteriorate, and for most animal species the food supply lessens. At this point a very critical event occurs: The species and the environment simultaneously begin to experience ill health. This can occur in many ways, including one that we may be witnessing at the present time: I think that is what the coronary studies reflect. One of the reasons we

Table 2

DEATHS IN THE LIPID RESEARCH CLINICS CORONARY PRIMARY PREVENTION TRIAL

Cause of Death	*Placebo*	*Cholestyramine Resin*
Coronary heart disease (CHD)	44	32
Other vascular	3	5
Malignant neoplasm	15	16
Other medical causes	5	4
Accidents and violence	4	11
Total, all causes other than CHD	27	36
All causes other than CHD, other vascular, and accidents and violence	20	20
Total, all causes	71	68

Lipid Reseach Clinics Program, JAMA, January 20, 1984.

Figure 5
HEALTHY SYSTEMS

Characteristics	*Natural System Examples*	*Human Examples*
Diversity	Multiple plants and animals in healthy natural systems	Diversity in diet Diverse approaches to problems Approach prevention at multiple system levels
Regenerative	Prairie grasses formed Iowa's topsoil	Restore impoverished land Healthy food growing
Healthy connections with other systems	Prairie run-off produces clear water	Awareness of what we pour into our air and/or soil may end up in our food and water
Responsiveness to local situations	Beavers build canals to food Goldfinches nest when the thistles bloom	Every local situation is different with different local problems and solutions
Perseverance	"Weeds" keep coming back	It will take a long time to accomplish what we desire
Non-violence		A uniquely human potential

have great difficulty in visualizing such events is that they occur over a period of centuries, or maybe even longer. We can look at world population and we can see over the last several centuries that human population has been growing at an expotential rate. Deterioration of the environment is occurring and deterioration in the health of the human species is also occurring as a concurrent event.

Conclusions

I think the concerns for the health of environmental systems and their impact on human health will become the most important health concern for the rest of this century. Some of these problems can seem overwhelmingly complex. But there are also signs of hope, and some tools we can use to help.

With these complex problems that we face, systems science may be our most useful tool. And, as we have seen, natural systems have certain characteristics that suggest a system is in good health. Figure 5 lists some of the characteristics of healthy systems, along with examples from natural systems, and some examples that may be of use to us in our own human systems. It matters little whether we refer to natural ecosystems, family systems, or social systems.

There is a simple way to learn and apply these characteristics of healthy systems. We can establish sanctuaries. A sanctuary is a consecrated place, a place of refuge and protection. They can be established in a corner of a home, an institution, a community, or bio-region. They can be already healthy systems, or systems made healthy by regeneration. It is in the sanctuary that the human species can see, and more importantly feel, that we are a part of, and not masters of the earth.

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