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Crash Course in prediction and mitigation for a crashing system: a complex biocultural sociological perspective of sudden social decline

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Aim: To present a condensed but inclusive discussion of the nature of the complex global system and the impediments to, but advantages of, means of prediction and action in a rapidly declining society To offer a compendium of the potential and difficulty of predicting complex social systems..

Research methods: A review and synthesis of research material on: the function of dissipative systems, most specifically the global social system; the means to discern, measure and assess three kinds of energy through functional networks; the intractable difficulties with prediction and agency.

Conclusions: Regardless the inherent difficulty in prediction and agency in complex systems, there is a benefit to having some methodology. That is, it is better to understand how the system works, and to be able to identify, if just a short while in advance, what might happen and what responses we might have, and to do that we need to have an organized way to look at things.

Originality / value of the article: Offers, to a broad variety of large and small organizations, a brief guide to conceptualizing the global system, its functioning parts and sources of energy, and the imperative and difficulty of predicting and strategizing for changes in a declining system.

Implications of the research: There is benefit to a thorough understanding of the complex social system, if it allows prediction and response to system changes.

Limitations of the research: It is a "crash course", and ideas are explored but not exhaustively described.

Keywords: complex systems, disaster management
JEL: D91, E71, H12

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1. Introduction

The usefulness of prediction, the importance of weather, some basic definitions, and a note about the essential nature of energy.

We recognize that climate change (Ripple et al. 2020), declining energy availability (Raimi et al. 2022), and global unrest represent situations with significant risk to families, groups, corporations and agencies (Braha 2012; Barrett 2022). The ability to anticipate, strategize, and respond is extremely useful in the best of times, but essential in the worst of times.

This crash course assumes a family, group, business or agency has no methodology[1], that is, no logical way to proceed, in place to anticipate and prepare for system disruptions, except the first line sort: there seems to be a food shortage, store food; there seems to be a budget shortfall, cut expenditures (Zou et al. 2012). Though this crash course is rich with ideas, some of which might be an unfamiliar description, it is intended to be accessible to everyone, and the ideas should be consistent and, we hope, logically ordered. It is intended to give the most information in the least space. It is arranged in outline form, in order to most easily group ideas. However, taken as a whole, the paper briefly describes: the nature of the global social system; our participation in it; the meaning of energy to the system and how to think about energy; a description of a few ways of searching for and organizing information; the necessary shortcomings of even the best methods, and the importance of having a logical way to look at these features. While acknowledging the real world constraints, the paper nonetheless demonstrates that the process of understanding and responding to changes in a declining society is important.

[1] A “methodology” is a paradigm, a way of looking at the world, which allows us to make logical inquiry. It allows us to organize our efforts. It provides us with a way of identifying what data we need to know, and how to try to collect data or information, and how to make sense of what we find.

2. Important definitions

Words are how we make sense of ideas. Many of the ideas we need to use are complicated. It is important to establish what we mean by certain terms, and how each fits with other ideas in our understanding

Dissipative system[2]: a pattern through which energy is organized and maximized. It is not equilibrious, meaning, it exists by exchanging energy constantly. Though such a system can display considerable resilience, meaning, it can suffer a loss of energy or efficiency and stabilize again, return to its state, (though perhaps slightly different), it is possible for the outcome of even a small perturbation to effect a seemingly disproportionate change in the system. The system exists to be discussed because energy is organized through the irreversibility (Zak 1996) of time, and the aspects of nature we roughly describe as the Second Law of Thermodynamics (Prigogine 1977). We can, for convenience, consider a system as inflow, through flow and outflow. We might refer to these as "complex" or "dynamic" systems. Such systems, for example, our weather, can change in ways which are, to us, unpredictable, though since complex systems are ubiquitous, we must try anyway (always carry an umbrella). Complex systems age, that is, lose efficiency and so cohesiveness.

Energy: is the substance of the dissipative system; energy is things happening, or "work" (Elert 1998–2022) being done. For our consideration, there are three kinds of energy: debt, agency, and physical energy (a bit over simplified would be "money, people doing things, and energy like burning wood or capturing wind, or riding gravity down a river"). Here we note that a dissipative system will function best when using the most energy it can get, called after Lotka (1922) "Maximum Power Principle", later developed by Odum (Odum, Pinkerton 1955).

Flow: energy moving; life and the universe. It is flow that we consider when determining the resilience of a system; we regard flow when we analyze networks. Flow has laws it obeys, for example, Fick's laws on diffusion (Fick 1855); Fourier's

[2] One of the pioneers of the study of self organization was physical chemist Ilya Prigogine. He approached what he called "dissipative structures" from the paradigm of the Second Law of Thermodynamics. Those familiar with Prigogine will recognize that the paradigm we use here regards dissipative systems, which generate structures, incorporating Systems Theory with Prigogine's insights on the self-organization of systems.

law (Fourier 2009 [1822]) in regards to how heat energy flows from high density heat to low, or the laws, most easily seen in biological sciences, of surface area to volume, which explains why, for example, larger animals have more complicated circulatory systems than small, and why there are no huge singled celled organisms. In general, we can find that flow follows the path of least resistance, and when flow is restricted, pressure or heat or social unrest, build. It is convenient to consider flow as energy over time, below.

Linear and complex/dynamic systems (Ladyman et al. 2013)**:** In simple terms, a linear system has once thing reliably following another. We like linear systems the best because they can be predicted, and we do know what a response will bring. Whenever possible, we "linearize" a complex system by isolating aspects and then recompiling them. A complex system, which nearly all natural systems, like our global social system, are, is both determined[3] and unpredictable. Complex systems are reflexive, meaning each instance is influenced by the previous instance, but while the idea of "path dependency4" meaning there are preexisting conditions into which a new event emerges, and it is likely to be much like those in the condition already, but, that history is not necessarily its destiny, as it would be in a linear system.

Network (Barrat et al. 2008)**:** a network is a process; networks are represented as structural pathways which connect near and distant parts of the of the system, and can be considered subsystems. Energy travels both ways in networks, for example, products go out and profit comes back. Networks use all three forms of energy. However, it is key to remember that a network is a process. We can consider it as structure, which means a pattern we can see and experience, that has some reliability.

Nexus/Nodes: centers where energy is directed through networks. The words are often similar in use; here we say "nexus" to mean a significant through-flow from many different sources, whereas "node" will mean a terminus or niche system. The

[3] The term "determined" here needs to be put into context. It appears that complex systems, and all the universe, is endlessly unique, that is, on a variety of measures, no two things are exactly alike. Each instant in the universe, and the position of every element, happens only once. Further, as each instant is the iteration of the products of all processes, there can only be one outcome from each instance. However, the determined nature of dynamic systems is not important for our discussion because it is unpredictable to us, due the limitations of the prediction we can do.

[4] The idea of "path dependency" is not without benefit, it is, I think, artifact of the way the system works, and not really dependable for a declining social system. Consider this: Vergne, Durand (2010).

key concept is that they are centers where different networks function, which help give form to the structure of the social system. Think “cities”.

Niche: a micro level of activity; the lower levels of energy distribution; often the last opportunity for the system to use energy. It is here that we live. Like plankton, niches process huge amounts of energy, a tiny bit at a time. System change often emerges from niches (see Schot et al. 2007)[5]. Like the tiny whirls that form just above the bottom of a flooding river, niches can exist for only a short time, or can display significant longevity. It depends on the flow.

Structure: the patterns of organization in a dissipative system. Structures organize humans (Crossman 2020), and arise from humans acting, which is a positive feedback loop to persist the structure. A government is a social structure; a bank is; an elementary school is. Dinner in front of the TV is. Structure seems fixed, but is actually recreated instant to instant, as the flows of energy pass through. We might think of structures like waves forming on a river, never the same water from instant to instant, but a recognizable form.

Surplus: the capture of resources which do more than power the system in its current state. Surplus is needed to grow and reproduce. It is the seeking of surplus that motivates living systems (Van Valen 1973), and social systems. The idea of energy surplus is critical to understanding why people do as they do.

Time: we use a simplified idea of time[6]. It recognizes that time is a measurement to which other things can be compared. So many miles per hour; so many times a day; time by sea and time by land. In many of our considerations, we will be thinking of energy across time. In this instance the importance is to recognize that scale has its own relative time. Indeed, time is a critical consideration, since food rots, people age, events take place, and all of these, for example, are instances where fossil fuels have given us back time, in terms of distance for the transportation of, perhaps, food, and for the time it takes for information to disseminate. In considering the state of a network, for example, the manner in which it consumes energy over time can inform us of its functionality and perhaps resilience.

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[5] Consider this paper which regards how a single morphogen (building from Turing’s 1952 paper) can generate novel and robust pattern spacing, for example, in multicellular development (Wang et al. 2022; Turing 1952).

[6] In physics, “time is what the clock says”. That is the simplest, most utilitarian description of time (physics has much more to say about time) and it is the one we will use here.

3. Fundamental assumptions.

Ideas which are essential to understand before beginning.

A first remark, pertaining to the nature of our building crisis: all history is made by weather. Here we note that "weather" is what people experience, whereas "climate" refers to the larger scale of meteorology. What we discuss regarding our crisis is climate change; what people will experience is change in weather. It was changes in weather that influenced our species hybridization from ancestors (Potts 1997), it was weather that sent homo out of Africa; weather that sent the different steppe peoples down to terrorize neighbors (DiCosmo et al. 2018), it was weather that beat the Spanish Armada (Lamb 1988); weather that drove our numbers from a few tens of millions to eight billion, and it will be weather that dramatically reduces our number. Responding to rapid changes in weather will place a tremendous drain on our global energy supply.

Two essential aspects of our study relating to the function of energy, which are key to understanding the task of prediction.:

1. All the systems we study must capture and organize energy to persist, and even more energy to grow. To that end, when possible, systems seek surplus energy. Since accumulating surplus accrues increasing cost, it is the function of most systems to seek surplus endlessly, ceaselessly, even when the system has passed maximum efficiency (Montemayor-Aldrete et al. 2014).

2. In nearly all instances, only one measure is primary: **energy return on energy investment** (EROI). In many instances, the return is not immediate, and so the system carries a deficit until the process is complete; a deficit is negative surplus, and carries risk. For the modern world, the real benefit of increased physical energy has been the influence on time and space; energy moving things swiftly around the globe, and so cheaply. Finally, when energy is transformed from one form to another, some is lost from that transaction. Our methodology, or our paradigm, meaning, the logical description from which we will base our investigations of the system, includes those aspects, which might at first, seem disconnected, but which function together as ideas to explain and illuminate our effort.

Gritty reality: knowing what is coming can help us prepare, but there are many impediments which we must work with, or in spite of.

I. We want to predict the future, and know what each of several possible courses in response will accomplish[7].

1. But, we almost never can. Prediction (and subsequent predictions about each of several courses) works best with linear systems, but even the simplest linear systems can display complex behavior. With complex systems, prediction becomes less certain, and subsequent predictions, rapidly less accurate. Hence, it is easier to predict in the short range.
2. There are epistemological issues, by which we mean that our ability to determine and understand the outcome of our predictions is limited. For example, the process of making a determination would include such actions as setting limits and thresholds; assigning values at least in part, arbitrarily, to variables; and indeed, the criteria and designation of variables. We bring with us a range of preconceptions, all expressed and shared in language; our traditions, official nomenclature and vocabularies, all add bias to our work. Language is its its own problem: regardless our efforts to concretize the meaning of words, the meaning is always dependent on context, and the individual's understanding of it; as Wittgenstein said, "the meaning of a word is its meaning in use" (Wittgenstein 1953, §1). Our search for a sound prediction is muddied by our methodology, and the natural limitations of being human.
3. Therefore, even before we begin to wrestle with the uncertainty, we have reached limits, and those limits are compounded when we use the outcome from one determination as the basis for subsequent calculations.
4. This is a crash course: it is not a primer in statistical methodology, but a paradigm, a model formed of related ideas which serves as a way of looking. We will deviate very little from human efforts to predict future events, from watching the cones of pines and fur on animals to predict the

[7] Consider this prediction from the Center for Strategic and International Studies: https://www.csis.org/analysis/predicting-future.

approach and severity of winter (when many of our ancestors would have died), to the guts of animals to foretell the outcome of war, to the machinations of complicated equations to guess market behavior. By this, we mean we can only work with what we know, and must, by some means, project that forward. However, the future is never the past, and, while relatively stable systems do allow for generalized, relatively short termed prediction, ultimately, complex systems remain both determined (they must resolve a specific way) and unpredictable (because the next state is not linearly associated with the last state).[8] Even so, we wish to know.

Discussion: predicting the future has always been big money (Iannaccone et al. 2011), and most often associated with gods or demons. Today, our religion is science and mathematics, and so we use those ideas to make our guesses about the future. We consider that, though every act we make has some element of risk, it is better to make the action within a logical framework, than to act with no logic, and no paradigm to guide our next act.

The fluid reality: complex systems are about flow. That should inform everything we consider.

II. The universe, even the social universe (Burgelman 2015), is composed of complex systems, most of which can exhibit dissipative and conservative dynamic aspects (García-Sandoval 2016). Dissipative systems are described as "self organizing", and one nice example is when molecules arrange themselves into a human being, which is a creature that maintains

[8] Some readers will be familiar with the aspects of "determined" and "absolutely unpredictable" as being related aspects of very complex systems. However, many of us wish to ask, "if it is determined, then why cannot we perfectly predict it". The answer lies in the amount of data needed. Our models and predictions fail in the long run, because complex systems seem somewhat random or chaotic, they are not, and are essentially rooted in a universal context. And, indeed, so much so that a distant decimal place in a number in our calculations will eventually cause our model to diverge from the course of the system. As is described in the text, in order to have all the information we would need to accurately give a long term prediction, we would need all the information in the universe, because processes distant in space-time will ultimately impact our system in unknowable ways.

homeostasis and even mind, by balancing internal and external complex dissipative systems. Such systems are not in equilibrium, and are often far from equilibrium (Socolar 2003). Certainly, we can only survive by immersing ourselves in, and negotiating, a context of dissipative systems. The global system is complex, and it also maintains structure by balancing lower level complex systems.

1. Systems of all kinds do this organizing without consciousness or emotion but only by winnowing energy and passing it through smaller and more distant networks. Here, it is useful to imagine turbulence in a mountain stream, where the energy of falling water is spent in large and increasingly smaller whirls and eddies, some of which persist but many of which are transient. It is key to understand that the water may seem to slow, but the eddies and whirlpools are structures that persist because water passes through. Our bodies function in this way; our families and local groups, our corporations, our global society. We can call this aspect of passing energy through increasingly smaller subsystems "elaboration" and it is a conservative aspect of the system.
2. The system will always seek to grow; when growth in one configuration is maximized, it will move to a more integrative configuration, increasing the number of networks and nexuses/ nodes in an organized way. It will ceaselessly follow energy, and never stop striving for surplus.
3. It is important to recognize that change often comes to the entire system from these elaborations on the fringe. The fact that niches on the fringe can and often do change how the entire system functions, makes prediction even more difficult.
4. The systems we wish to know about can seem both strange, and yet thoroughly familiar; it is the familiarity, the features which remain the same from one kind of dissipative system to another, that allows us to make guesses about things we can not know.

Discussion: We are "of the world", meaning here that energy from complex systems runs through us. We are often deceived and often wrong, but our efforts to understand the world are logical within it because we came to be and have been sculpted by these systems, they are us and we are them. We should be encouraged and a little awestruck by this.

The three energies: human behavior, debt energy, and physical energy. Understanding the nature and value of each.

III. The human global social system runs on three kinds of energy.

1. Human activity. Humans have propensities, inherent behaviors, which explain most of what most humans do. Humans are "rational actors"[9], which means they take actions which seem reasonable to them, at that moment, in that context. We note that not all humans have to exhibit these propensities, just most people. The system will run fine and the species will continue, and since much of human social behavior is constrained by other humans in any case, many do what others like them do.
    1. Humans want to live, and have consanguineous and fictive kin live. Reproduction is part of this.
    2. Since all humans live from the surplus of the system, affiliation, or interacting with other humans, is ubiquitous and essential to life. Modern humans are so social that some biologists have classed us nearly eusocial, like bees and termites (Nowak et al. 2010).
    3. Because of this, social interaction between people (networks) is founded on a relationship between three variables: similarity, familiarity, proximity. Humans live a relatively long time, and nearly all need other people to survive, and there are often many interactions in a day; humans keep a rough running tally with people they interact with often, or who interact infrequently, but significantly (for example, your boss, perhaps). The tally is rarely found in words; it is the more basic parts of our brain that keep track of those interactions.

[9] Like most such concepts, the term "rational actor" is challenged based on expectations of what is "rational". We collapse those competing points of view to this: a rational act is one which the actor perceives as the best one to achieve a long or short term increase or maintenance of access to the surplus of society. From outside the experience of the individual, bystanders may speculate on whether the act was rational in what was accomplished. That has no bearing on the meaning of the word in this context, it is the experience of the individual in that context, in that instant.

As a result, one might react to one person with dread, because the interaction tally is unfavorable, and another delight, because they are generous. For this reason, one seeks to be seen as reliable, and dependable, to their status group of kin, fictive kin, associates and other types of networks.

4. A feature of that contest for status is the concept of "relative deprivation" (Stouffer et al. 1949). This means that each individual compares her or his status with others of his or her class and group. This simple distinction, a result of the difficulty of climbing well above one's status, provides cohesion to the hierarchy.
5. The surplus of society represents continuation. As a dissipative system, each person needs to seek something for today, and something for tomorrow. This need to find the energy needed for life tends to cause people to seek more access, more surplus.
6. Access to the surplus of society, or, authority and legitimacy, is central to human life, and so, the regard of others is important. Each person has status in different contexts, each with its own rights and liabilities. Hence, in nearly all human societies, and certainly all human "civilizations" individuals are heavily webbed with networks of status. Laws, mores, value systems, taboos and the like function as structure for the playing out of the distribution of surplus through status.
7. A significant aspect of having several positions of status, or "roles" is that they are extremely context based. The context is nearly seamless, it wraps around us, we understand it and our emotions drive us in each instance. We have social markers, such as vestment, ornamentation, setting, and greeting which help us understand quickly what the meaning of the interaction is. Two people approaching each other on a quiet street make many evaluations of each other, even from a distance. Gender, age, and even status is often identified swiftly, and by the time they pass, each knows the short menu of actions they can take, from no obvious notice, to a nod, to a

ritual utterance (good morning), to robbery and murder. Each interaction between two or many people plays out in a manifest stage, and, often in a secondary (or "back stage") context. We refer here to "dramaturgy" (Goffman 1959); we each have different roles; sometimes we play them at once (husband, father) but sometimes the roles are discordant, out of harmony (husband, office paramour). By this, we mean that the role of "father" and the role of "law enforcement", for example might come in to conflict, causing stress, or "cognitive dissonance" (Festinger 1962). As a result, the relatively few variables of roles available, in complex interaction, yield a richly elaborated social world. In other words, in acting out the roles in the real world, the actor might pick one of several possible courses. We might like to guess which each will choose, and indeed, most will chose one of just a few possible actions, based on their personal context, but because the interaction between roles allows for complexity, we can never guess all possible responses.

8. The system of status allows for a necessary function of the current global system: elites. No complex society and certainly no civilization has existed without an elite to organize society to seek and distribute surplus. There will always be an elite; however, not always the same person or line. Wealth and power, in other words, a system of larger share of surplus from society, are surprisingly long lived (e.g. Barone, Mocetti 2015; Corak 2013).

2. Physical energy is the easiest to understand. This is the energy which powers the universe, the planet, and all life. Energy does all work. The system is the flow of energy. Social complexity is dependent on energy; low energy surplus means low complexity. Likewise, businesses and families; more complexity, more parts, more networks means the cost of, and opportunity for, more energy, in other words, energy return on energy investment (EROEI).

1. Human power was our first energy: individuals foraging. Human power was also our second energy: slaves, who labored and

surrendered the surplus of their labor to someone else. That pattern has continued for an unknowably long time, and is represented as wage slavery and variants today.

2. Subsequently, we had wood, draft animals, wind, falling water, coal, oil and gas, nuclear, and, of course, the primary source of energy for all others: sunshine. Only sunshine does not pollute; all sunshine derivative systems produce waste in the process of using energy.
3. As the available physical energy increases, other forms of energy also increase. The system grows. Too much energy can overwhelm a system, causing it to break down to new, lower level systems which have more room for growth, and often eventually compete with each other, as part of the process of re-integration. (Shall we think of Britain after the fall of Rome[10]).
4. As available physical energy decreases, the system, first, evidences trade-offs, cutting energy to some niches, and giving it to more critical nexuses. Next, parts of the system might seek new sources of energy, competing with other parts. If energy continues to decline, more niches disappear, though new ones appear to take advantage of energy which is not organized. As less central, less busy networks and nodes disappear, the system begins to lose integrity. Large areas of the system may reduce interconnecting networks, responding to the sources of energy not organized by the larger system. The system becomes unstable. Continued decline of energy (at some point inevitable because the system no longer has the complexity to organize energy in lessor or more distant nodes), or a perturbation from outside the system, can cause it to collapse.
5. Collapse is often relatively swift, sometimes incredibly swift, with networks and nexuses disconnected, and energy unused, or, used inefficiently.
6. If the energy is otherwise available, the nexuses and networks of the

[10] In Britain after Rome left, the power vacuum allowed the creation of many small kingdoms, which, over the course of five hundred years re-coalesced into Great Britain (Sawyer 1998).

collapsed system can be organized by lower complexity, or more distant, systems.

7. Physical energy is a necessity to the social system to feed, house, and organize eight billion producer/consumers.

3. Trust, by which we mean debt, including money.

   1. Trust, or debt (money is debt, a value trusted to be reclaimed for goods) make the global system possible. It allows surplus to be accumulated efficiently.
   2. Debt allows the system to move resources over distances, and even over time. Debt is necessary for higher complexity networks to form and nexuses to function.
   3. Debt can organize human and physical energy, it has flows which feed the system.
   4. While all debt carries risk (it might not be repaid), the opportunity to organize other forms of energy often returns more energy that energy invested, due the concept of "interest", which allows profit and encourages participation. "Insurance" is a hedge against that, by which the risk of one person is spread over the profit of many, and insurance can be considered further elaboration of trust.
   5. Plenty of one kind of energy can compensate for a shortage of other kinds; however, when transferring one kind of energy (say, debt) into another kind of energy (perhaps workers) energy is always lost to that exchange, to be captured peripherally.

This should be IIII nothing I did to it would make it IV. It is critical to understand the importance of structures. A social structure is any behavior which leads people to do the same thing, either over and over or one after the other. Structures fill critical needs and are quite resilient.

IV. Structures are patterns which form in the system, and which are reflexive, meaning they are formed from the repetition of flows, and by existing, change the flows.

1. Social structures arise from the functioning of the system, and organize the flow of the three energies.
    1. Social structures are dynamic, changing constantly. Some social structures are formalized, but many are just habitual.
    2. Social structures set the "symmetry" of social interaction. Formalized social structures are "social institutions", which interface with people, and are represented by buildings, for example, often with official symbols, and documents, and layers and layers of bureaucracy. Often, special vestments are worn, designating status within the institution, and in society generally. However, many structures in the flow of daily life are not manifest, but are implied. The behavior of a crowd at a busy hot dog stand.
2. Bureaucracy, the carefully delineated organization of humans, is the networks and nexuses within the institution; energy flows from designation to designation, usually one level of information from supervisor to field worker, for example, and a different kind from supervisor to manager, but the language and implications are the same, and generally authority descends from one, to a few, to more, and then to many. Surplus energy moves upward, where it powers the elite, and persists the flow of the social system. Surplus builds roads and hires armies.
    1. Labor, and purview, are carefully apportioned, because purview is authority, and boundary. It is important for our purpose to understand this, because the context of each position is different. By this, we mean that the individual human inhabiting the bureaucratic position lives in a different world from those above or below. The language is the same from top to bottom, but the meaning of the language changes because each position has different interests: things which, if done right, can bring reward, and if done wrong, bring loss of security and perhaps, status.
    2. Since structure descends from the manifest purpose of the institution to the manifold interpretations through context to each person, it is

represented within the individual, as perspective, or “world view”, which each person assumes is shared, but which are contextual, and so unique to the individual, and to the moment. This is because humans make sense in the now, and, even when remembering something, it is created anew in the now. Humans, like all complex systems, are dynamic and ever changing, even if they seem not to be.

3. We recall that change often comes from the niches; this is easy to understand: each niche bears the symmetry, the relationships between its parts, with the larger system. However, each is also slightly different. When stressors cause perturbations in the stream of energy in the system, niche systems find a changing context, and with a relatively broad variety of differences, some will take advantage of the change in stream. Here, we think of a population of, for example, the finches Darwin found in his work[11], those who deviated marginally from the others then benefited from that slight change to become dominant. Individuals are micro niches, and at some point one or a few will bring change to the system, whether to institutions, or to group expectation, but to some element of social structure. There is no way to predict which will; we assume that kings and presidents, with their power to dictate policy, might be well represented among individuals who bring change to the system, but even there, most bring little lasting change; very few people bring change to the system, and when one does, she or he is likely nearly indistinguishable from many others like that individual prior to the change emerging into the society. This is because it is the system, the circumstances, the flows of energy, which select and nourish change, as a matter of function.

3. This matters to us because it reminds us that, at every level, even the personal level, what we want to predict exactly, is unpredictable beyond

[11] For example, see this which springs from the understanding of “Darwin’s Finches”: Gillespie et al. (2013).

some limited degree of certainty.

Discussion: We perceive social structure whenever we interact with elements which manage or change our lives, though often it is transparent to us, just context, part of the world as we know it. Because structure is dynamic, that is, because it is recreated over and over by people doing things within context, moving energy within the system, we cannot know exactly how it will change, or when, or to what. We can rely on humans to be humans, to persist and protect the structure that allows them to live and have access to surplus. We can rely on people to do things over and over with some regularity, circumstances permitting.

Networks integrate the complex social system, move people, things, and ideas, and are less something like a road or a wire and much more process, that is, things happening.

V. When considering managing decline and collapse for your family, group, business or agency, a thorough network analysis is essential. It is the number, flow, and complexity of networks we use to determine where we are vulnerable, and what our possible alternatives are.

1. There are many formal approaches to network analysis, often using nomenclature and symbology. In our discussion, we use the terms "networks", "nexuses and nodes", "input, throughput, and output" which are common to network analysis, and, if your decision makers are in a position to do so, a formal methodology can be chosen to form the basis of the assessment of your networks. However, a system of your own devising, founded on the paradigm described here, will be fine, so long as it is thorough, and flexible, easily modified.

    1. Nearly all methods of network analysis represent networks in linear fashion; it makes sense, particularly when some of the networks we consider follow geographic lines; things move from place to place, even information moves from one place to another, following essentially, lines. However, we should not let the linear, even geographic, features of the course of networks distract us from the

importance of networks as being process, complex and not linear.

2. Geography is, even so, an important consideration (Bosker, Buringh 2017). As the movement of people and things and even ideas, declines with declining energy, distance becomes important, as it takes, usually, increased energy using a less efficient means, and a lengthening of time. Fossil fuels reduced time for things. In addition, geography is a primary variable in the appearance of cities and other nexuses and nodes, which generally form at harbors, rivers, crossroads, trade routes through mountains and deserts, and so on. Geography should feature in your consideration of networks. It will potentially impact your energy, and time.
3. It is logical, analytically, to apply values to networks. The value reflects the energy which flows in that network, either by volume, or the degree of influence. The value has to make possible an estimate of the energy return on energy investment, and allow possibilities for substitution or modification in your operation. It is convenient to use measures of debt in and out (profit or loss) in currency; human activity in person hours; and therms or watts of all kinds of physical energy. The value of the network, though, is not clearly demonstrated until the different measures are synthesized, and the importance of the network (for example, is it the sole affordable supplier of a product, or service) quantified to some measure, and given weight in the consideration.

4. An actuary is a critical need. An actuary ceaselessly gathers information, and using statistical methodologies, assess value and risk. The term is associated with business and insurance, but is the best fit for the job we require.

Discussion: A network is a process, a system, and is relative to many other networks, systems. To understand our situation, and understand where problems might arise, and what we might do to, we need to place ourselves as nexuses of many complexly related networks. We must develop ways of determining the importance of each to us, and determining how to respond if one, or an associated number of networks, goes down. We need to examine which networks are most impacted by a decline in physical energy, and consider that change to the other two forms of energy, what people do, and how it is paid for.

The best methods use some form of statistical analysis; however, those methods work best when the system is stable.

V. This should be VI Statistical analysis and modeling in societal decline becomes more complex.
  1. All modeling demonstrates what we have already discussed:
     1. there is a limit to the data one can gather and crunch, and data from sources that might become influential is often left out from consideration;
     2. the systems remain unpredictable, though determined;
     3. the model must, itself, derive from observed real world data;
     4. the problem of nomenclature, criteria, and definitions remains;
     5. toward this end, we use an "interdisciplinary" (Tobi, Kampen 2018) approach, by which we "regularize" or normalize information from different perspectives, finding equivalencies and ways to compare things from different approaches in language that works for us.
  2. Nearly all models are constructed by considering historical data and identifying variables and creating models which can, to some modest degree, replicate that past behavior and cast it forward to predict the future, that is, to "imply" an answer, or more likely, a "distribution" of possible answers.
     1. in a stable environment, that has some efficacy for short term predictions;
     2. however, most are best at showing only certain relationships;
     3. the effort is facilitated by a thorough understanding of the networks and energy distribution (right down to wooden pallets);
  3. Multivariate analysis (Chatfield 1980) and modeling is a formal approach to the informal process we discuss here.

1. multivariate statistics and analysis systematically attempts to discover the relationship between variables;
2. it measures "distributions" of outcomes, meaning it looks for relationships between the different variables, and implies some patterns of relationships. Those patterns suggest what might happen;
3. it looks for "latent variables" (Little et al. 1999), in other words, influences which can not be immediately observed, but which can be detected through the behavior of other variables. There is always the possibility that the artifact comes from no identifiable variable, but from the function of the system itself. In short, when the behavior of a variable is not well explained by the process, invisible influences must be explained. The difference between the expectation and the result can lead to new patterns, some of which might be artifact, that is, a result of the proposition and perspective, and not the system;
4. like most such processes, most multivariate analysis finds "dependent" and "independent" variables. It is assumed that the dependent variable demonstrates change from the independent variable, for example, it is the speed of the baseball we measure; the bat is assumed to always determine the change in the ball's velocity and trajectory;
5. this is problematic, because what we really care about in this analogy are the factors which influence the velocity and impact point of the bat, which makes that the dependent variable, and all the processes which impact the batter;
6. as a result, the analysis must "slide" from one focused relationship to another, in which the initial independent variable is the dependent variable. This might require a change of focus of analysis to a different scale, which might require new nomenclature, definitions, criteria, thresholds and so on;
7. and, so, the formal process is energy intensive in human and computer time, is very slow, and still works best in an environment which is either stable, or declining at a steady rate;

8. if informed by network analysis, multivariate analysis has application in our effort;
4. Dynamic analysis is a methodology Brandon Tuma et al. 1979), which, at its simplest, analyzes values and considers what patterns might be revealed by that perspective. In its simplest form, it does not assign values to variables, but just considers, typically, amplitude and periodicity: earthquake (Wilson et al. 1972) analysis is a quick example. When possible, this approach, coupled with multivariate network analysis, can provide insight into the severity of different changes.
5. If your family/agency/corporation has the debt, human and physical energy to maintain formalized multivariate analysis, engage it as a tactic; in any case, the decisions are still made by you.

Discussion: We must have some methodology, some regularized way to gather data, interpret it for our purposes, and some informed rationale for potential responses. Whatever form of analysis we choose, there will be shortcomings which arise from the perspective, the sense we make and the values we place on data. If it is possible to use advanced multivariate analysis to inform your decision making, use it. If not, do what humans have always done, and use what methodology you do have, understand its limitations, and take the best actions available to you.

As we know, things do not often go just as we wish, and our strategies do not result in the changes we wish. There are several reasons for this.

VI. This should be VII There is a problem with decision making and agency. "Agency" is the ability to change the system[12].

1. One problem is that we are fully embedded in context. We are literally part of the flow of social energy, it permeates us, we have lived within it every instant of our lives. No human can live without culture, which is

[12] We distinguish between agency and "free will". Free will is an illusory idea, mostly used in religion, that the person can make moral choices. The idea of free will is easily diminished by simply considering the processes necessary for a will to be "free". Here, we discuss agency, which considers the degree of embeddedness of the person in context, and the likelihood of changing context.

the system, and no human has, since before the emergence of Homo sapiens[13], 300,000 years ago. Everything we feel and know is derived from the system. It is possible we cannot make, or even conceive, of an action which is in any way separate from the system, and the control it has.

2. The system is reflexive; whatever you do is immediately the product of a process in the system, and, variably in concert with other processes, changes something in the system, and all the system responds. The response is novel, and not constrained by your purpose. This is commonly referred to as the "unintended consequences" (Merton 1936) of the action. Make an action: it goes in to the system and work is done, energy is spent; and a result is observed. The result might be as expected, but in addition to the desired result, an undesirable result also is observed. Now, the choice is to decide, is the result sufficient for our purposes; is there a positive net energy from the action, or do we need a different approach or some further mitigating action? Both require energy. The mitigating action will also have consequences, some you might prefer, but others that cost energy. Just as our predictions on the system lose accuracy as subsequent predictions are based on those predictions, our subsequent action will have less efficiency, and perhaps more unintended outcomes.
3. Strategies which seem sound might have tactics which are counterproductive or cost energy. This applies to all strategies. Above, in the discussion, we addressed that, in any social organization, the intention of management has a shifted meaning as it moves down through the organization, because the context of the worker is different from that of the manager; each have different demands on their actions. It is that same thing: the strategies created in a meeting and decided on by authority in a warm room, for example, shift meaning when they are operationalized in the difficulties of the field. If the control of the strategy is too rigid, the

[13] Culture has long been necessary to capture enough energy for our line. The stick was a great help, and then the stone, and the ligature. However, our cultural use of energy took a giant leap forward with the controlled use of fire. This was a million years ago, about seven hundred thousand earlier than the emergence of even early Homo sapiens. See: Berna et al. (2012).

lower level workers will waste energy, and in some instances would die. If the control of the strategy is too flexible, lover level workers will seek the easiest and safest course, and the objectives might not be met, and the energy of the tactical group is wasted. It is critical, when strategizing, to have as much real world data as possible, including input from the field. Of course, in many instances, we cannot know everything we would need to know.

4. Good strategies include alternative plans, should various hardships arise. Of course, this approach uses human, debt, and sometimes physical energy. In addition, as we know, it is not possible to anticipate every possible difficulty.
    1. For example, the sanctions against Russia in the Ukraine military action resulted in a short cascade of events, to cause a shortage of wooden pallets, necessary to move goods of all kinds all around the global system. Not only were Russian and Ukrainian pallets hard to get,[14] those places that made their own pallets needed Russian steel to make the nails to make them.[15] Using alternative formats, shifting to steel pallets, for example, increases energy cost to make, and to ship, and plastic pallets are lighter and less costly to make than steel, but use oil for plastic, and are the result of a global collection of goods, such as plastic pellets, which also might require pallets to ship, for example. Wooden pallets were in use because they were the cheapest, meaning given the best cost efficiency, essentially being made in second level nations with plentiful labor and wood. Who, in February 2022, would have thought "we are at risk of bottleneck due a shortage of wooden pallets"? Likely only a few people close to the industry. Knowing early, what could they have done? Likely, very little, perhaps buy plastic pallets when they are cheap, but most

[14] https://www.seabaycargo.com/resources/Ukraine-war-worsens-wooden-pallet-shortage-as-prices-soar_37675

[15] https://www.goplasticpallets.com/news/could-the-nail-shortage-be-the-final-nail-in-the-coffin-for-wooden-pallets/

businesses in the global market run on “just in time” and do not have storage space for months of needed pallets.

2. Even so, it is worth spending energy to gather as much data as possible about the networks in which we function, keeping in mind the ultimate goal is to keep energy return higher than energy investment, in an inclusive sense of our system.

5. The primary occupation of managers during decline, and perhaps collapse, is to deal with, not just energy declines, but increased energy loss, as more costly alternatives are used to replace once cheaper processes or products. In a decline, and in particular, a collapse, all the supporting networks change, most often leaving the optimal state for a less energy efficient state. Hence, for example, if you can get diesel, a diesel engine is the most efficient use of energy. Without fossil fuel energy, you will have to use draft animals and humans, who require food and housing of some kind. In our example, in an agricultural context, it takes land to feed draft animals and humans which could have been used to grow a market product.

Discussion: We will discuss a scenario. Our company makes and distributes phlogiston gas. All product leaves the factory on trucks. Some trucks take the product to end users; some to distribution centers, some to rail heads, and some to ports. What networks are used to take one load of phlogison directly to the nearest customer:

1. What are our networks? We find them by understanding where energy flows: Administration, marketing, production, shipping, storage areas, loading equipment, electricity, insurance. Know all the many connections from each network to the others: all the personnel, physical plant, accounting. The list is not exhaustive, and each item has a similarly complex list of relationships, increasing the complexity and difficulty in accurate prediction. Even so, we must thoroughly understand the flows and returns on those internal networks, and where each connects outside our family, group, agency or corporation.

2. For example, we examine from the perspective of moving material: Roads, including governments, motor vehicle laws, enforcement of the laws, road maintenance, road construction and repair products, taxes. Again, there are things not considered, and each of those elements is webbed in with other networks.
3. Trucks, maintenance items like tires, oil, nuts, bolts, wrenches, garages and mechanics.
4. Insurance, both liability and product insurance.
5. Truck drivers, including certification and testing, wages and benefits.
6. Weather.
7. In short, virtually hundreds of elements, including, for example, shortages of critical things like spark plugs, which could happen for a number of reasons, including political or social unrest where a key component is obtained, processed or distributed.

2. Properly compiled, we see that we have literally thousands of variables to consider; indeed, a complete set of variables is the size of the universe. Each has, for example, vulnerabilities that we simply cannot know, and yet one of those could trigger a crisis in others. If the state government defaults, and does not maintain the roads, our drivers may have to take alternate routes, which might be longer or more difficult or even dangerous; there would be more wear and tear on the trucks; the drivers might want more money; the insurance might go up, and so we incur costs and so lose energy on distribution. If the roads are not maintained in bad weather, we might not be able to ship at all. Did we anticipate whatever destabilizing event that caused the state to default? If there were warning signs that default might happen, did we realize it might effect our shipping? If we had known, what could we do about it, beyond crafting contracts? Likewise any of the other many unpredictable, but still important elements which are involved in shipping one shipment directly to the nearest user: do we use Ukrainian or Russian pallets or pallet nails?
3. As the length and number of exchanges in other deliveries, such as to a rail head or port grows, so does the list of small things which might

impact our business. Even so, there are structures even in the life of the system, and things will go wrong, most often, in related batches. We can easily see how this is, since the nexuses and nodes and other structures which suffer a loss of energy share things in common with other nodes; some aspects of their existence are held in common; perhaps it is a supplier of raw materials, perhaps a road, perhaps a consumer group, perhaps just the relative position in the network, which might not be proximity.
    4. This is how the world has always been for our species, since long before we left Africa, and, defying all odds, here we are!
2. We obviously cannot know everything we need to know to manage in decline. However, we are not without some understanding of how key elements of our system works. We can plan in preparation for a downsizing or other modification of purpose, in general ways. Planning is strategy, what will the tactics be like?
    1. In the real world, there might be few alternatives. Things families, governments and companies have typically done are the reasonable things that can be done:
        1. If shipping is threatened, for example, by a product availability crisis that hits both road maintenance trucks and our delivery trucks, we can make more use of alternative shipping, taking more loads to rail heads, so preserving truck resources. We might pay drivers less, cut benefits, pay by the load and not by the hour or mile; if other truck driving jobs are available, our best drivers might leave, reducing the effectiveness of the delivery system. We might delay truck maintenance but continue to drive (ultimately costing us trucks). We can charge more for shipping, but that would discourage users, unless there are no other phlogiston producers who could provide it more cheaply. If we were the sole source and our costs went too high, our users would, in turn, try to use less product, or find alternative products.
        2. If shipping is significantly damaged, we would experience energy

shortages in other areas, as we struggle to maintain inputs, and then delivery. At some point, we might have less demand for our product than our system produces; we might have to reduce production. But reducing production means idling equipment and personnel. Perhaps the machines that make phlogiston, like the machines that make many other products, cannot easily be shut down; perhaps they need to be idled at a certain temperature. Perhaps if we shut machines down, it might be difficult to restart. As we make less product, our company begins to decline.

2. The decline in company surplus as determined by the actuary, is the alarm that triggers a modification of our strategy, and perhaps our mission.
    1. To the degree possible, we should already have a strategy for that situation. We have already considered the networks to which we are connected, to two or three “degrees” of relationship. We have already researched the possible information to answer key questions: Can we make something else? What, related to what we can make, is in demand? Can we use our facility with different inputs to produce a new product, or an old product which is back in demand? Is it easier to ship than phlogiston? Could our market change so we deliver our product to stores for popular consumption?
    2. Before deciding on a strategy, we test it in our discussion against others. If a first line network is damaged, what other first line networks might be effected as well? Will the energy from the crashed network be captured by another provider? Is there a possible advantage in just staying the course?
    3. A system in decline is unstable and volatile. It is unwise to make changes which require a great deal of energy and which can only profit in the long term. The closer to actual collapse the system gets, the shorter “long term” becomes.

4. Conclusion: Regardless the seeming enormity of our task, we must do our best, since that is where our best chances lie, regardless all the uncontrollable factors.

VIII There is a tendency, at the start of a long term emergency, for people to cling to what has provided security in the past, from government help to gods. Even so, as long as life remains, analysis must be done; strategies must be devised; tactics must be operationalized, intelligence must be gathered, and all again and again. In a decline of energy, survivors will be flexible, will change standards, change goals, change world view. Eventually, as the standard of living declines, behaviors increasingly diverge from the old norm. That is, what might have been seen as unacceptable is grudgingly tolerated, and then becomes the norm, and might eventually be a virtue. Survivors will understand this, and be flexible.

The flexibility will be guided by attention to the stream of energies, to the propensities of people, and to the function of the system. In many instances, doing something has an advantage over doing nothing. Do something. It is what our species has done to survive this long.

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