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TOWARD A UNIFIED ECOLOGY

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the egg—depends arbitrarily on where each independent observer chooses to start. That is not to say that the chicken/egg loop is without value in solving the problem of chicken farming, but it is still arbitrary. We assert in chapter 9 that management falls somewhere between the landscape and the ecosystem criterion, and it integrates them. The landscape tends to avoid impredicativity, as it often uses hard semantics. By contrast, the loops of the ecosystem have chicken/egg written all over them. Management of ecological systems is therefore down-to-earth and concrete on the one hand, while being equally a matter of arbitrary design and measurement scheme on the other.

The concrete achievements of the hard sciences and their applied partners are so great that they distort our judgment. Hard science achievements can make the insecure in the firm but not hard disciplines reject narrative. Like it or not, the social standing of scientists roughly corresponds to a ranking from hard to soft. Accordingly, the temptation is to move to the hard science end of any given discipline; sometimes this strategy can be productive, but it can degenerate to mere calibration for its own sake. In ecology this problem is exacerbated by modern gadgetry. Often, we measure only because we can. And the review process of granting agencies accepts data collection over thoughtfulness about what to measure, a pathology in funding that needs fixing. Certainly, making easy measurements is cheap and sometimes data collected for its own sake reveals surprising insight, surprising because there was not really a plan. The downside is that we are buried in data that do not matter.

Premature hard definition can slow progress mightily. Grime (1985) cites himself as he quotes:

> In plant ecology as in golf there is a time for precision and a time for progression. Only in fog or acute myopia can the hazards of driving justify putting from the tee.

And he is right. We insist that a mistaken quest for the hard has slowed ecology to a snail's pace, when the large problems at hand demand swift action and bold moves. With narrative we can pick up the pace.

Ecologists are not trained to measure social factors, and they are simply at a loss as to what to do. Soft science requires rigorous training. Social scientists learn taboos, of which biologists and ecologists are unaware. But ecologists wade in anyway, particularly in management of human ecological systems. The big biological taboo is that "evolution does not plan ahead." The important social taboo is that outcomes in social situations are neither good nor bad; they are simply there. Joseph Tainter has noticed that this insight is rarely achieved without explicit training, which social scientists get but biologists do not.[12] Looking on the bright side, Tainter identifies that societal collapse may not be a bad thing.[13] Lower taxes and greater freedom for the rank and file is a good thing for that group, but that would not be the opinion of the elites. Inside any society is a set of values taught and agreed upon, as to what is good and what is bad. For instance, most of our readers would feel that the collapse of the first world would be a bad thing. The counterpoint is, "Well, that depends." Tropical nations, whose markets are dictated in ungenerous terms by first world cartels, would see a lot of advantage in industrial collapse. Bananas at 38 cents per pound in U.S. gas station convenience stores must be costing third world peasants significant income in return for long, hard work. Imprecision that inserts goodness into soft science settings is as bad as slovenly experimentation in hard science. Ecologists doing good should beware.

We were impressed when we engaged with our anthropological colleague, Joseph Tainter. As ecologists, Allen and Hoekstra with James Kay set about identifying what biogeophysical factors would give indications of sustainability as to whether or not a national forest was working well with its content and surroundings. We found workable but unremarkable factors and suggested some measurements. The biophysical factors were subsequently incorporated into a North American test on monitoring sustainability of managed forests and grasslands. Tainter made a separate contribution. In the space of a few hours, he suggested a long list of social measurements that could enlighten us in our quest. The list will open ecologist's eyes as to what constitutes social science rigor and clever measurements. Tainter's list was divided into structure and process. It focused in a way that resonates with the landscape/ecosystem tension we have already mentioned. For the sake of maintaining the flow in this section, we present only two examples of Tainter's suggestions here, and put the rest in appendix 8.1.[14] Any readers who are biophysical ecologists will be struck with how different is the social scientist's point of view. In the meantime, we can capture much of that difference with just one structural indicator and another that is a process indicator. Even the structural indicators include change of structure. As is the example we choose:

Is the rank-size distribution of communities within the ecological system management unit changing in a direction unfavorable to smaller sized communities?

The process indicators may not necessarily indicate change, but they are often about human processes, not their structures.

Are people's expectations of their communities future being met?

We note that the structural measurements that Tainter suggested were on the side of being predicative. Meanwhile, the process indicators have more than a touch of the impredicative in Giampietro's terms.

Joel Cohen said that biology has physics envy (see comparison between Cohen and Rosen in note 15, with the tension between predictability and impredicativity with real players).[15] The sad thing that makes Cohen's rebuke strike deeper is that mainstream ecologists envy Newtonian tidiness, not the penetrating logic of quantum mechanics. Confident in their material systems, physicists are free to press hard with soft devices like narrative. Hamilton worked in the 1820s. John Brinkley, a contemporary astronomer, said of Hamilton: "This young man, I do not say *will be*, but *is*, the first mathematician of his age" (emphasis in original). Hamilton tried to reduce optics of lenses to Newtonian particle behavior. He failed. So he had to write a dictionary with analogies to translate, rather like the translation of water pressure to voltage in the pedagogical analogy used in teaching electricity. When he had finished, Hamilton then performed a reduction on optics and found a waveform. This kept physics busy until Einstein. Rosen points out that if Hamilton had only gone to the Newtonian side of his analogy and performed essentially the same reduction, in the manner of Schrödinger a hundred years later, he would have found quantum mechanics.[16] So physicists regularly use metaphor, analogy, and narrative, when ecologists would not like to appear so soft.

Ecologists often mistakenly stick to models when what they need is a good story. Other ecologists have developed whole outstanding careers on powerful narratives; for instance, Paine's narrative of the intertidal animal community, or Likens's narrative of Hubbard Brook clear-cuts. There are few models that can map ecosystem processes onto a landscape, but narratives can handle the changes of perspective that are required. Likens kept changing his story as the forest kept revising the tale it was telling. It recently told him a rattling good tale about calcium and transpiration.[17]

In physics and chemistry, the observations are hard won, but once the complicated detection devices are working, hard semiotics appears to reflect very general situations. For most purposes, one does not need to make allowances for the differences between electrons. By contrast, at the soft end of investigation, human individuality dogs the investigator every step of the way. In more positive terms, it is exactly those human quirks that make the soft sciences such rich indicators, as was Malthus to Darwin.

The methods of the soft science disciplines may hold the key to dealing with the more awkward aspects of ecological systems, like developing methods for their management. There is a way to be rigorous and address larger issues, but it will be with a different sort of rigor. The best have been cleverly analyzing big data in ecology already. Tom Swetnam was faced with masses of tree ring data.[18] There are many reasons for trees to show a narrow ring in a given year; it might be drought or it could be pestilence. Some trees show epidemics in pestilence, such as conifers hit by spruce budworm. By separating out tree species that are susceptible to such focused causes of poor growth, the years of stunting with climatic causes can be identified. Clever use of data can give deeper insight than more or harder data.

We have already referred in chapter 1 to Wald's work on aircraft damage in World War II.[19] He suggested reinforcing places that were not often hit because planes that got hit there did not come back. Data are always set in a context that can be used as a lever. Ecology is learning about big data, but it is still, for the

APPENDIX 8.1

CRITERIA AND INDICATORS FOR ECOLOGICAL AND SOCIAL SYSTEMS SUSTAINABILITY WITH SYSTEM MANAGEMENT OBJECTIVES.

Social Indicators

Structure Indicators

Is the rank-size distribution of communities within the ecological system management unit changing in a direction unfavorable to smaller-sized communities?

Is the distribution of monetary incomes in the area of the ecological system management unit becoming more or less equitable?

Is the population age distribution among smaller communities within the forest management unit stable, becoming older, or becoming younger?

Is the number of locally owned businesses stable or increasing?

Is the number of businesses in smaller communities stable or increasing?

Is the level of economic activity among businesses in smaller communities stable or increasing?

Is the availability and feasibility of diverse economic pursuits stable or increasing?

Is the travel distance to basic goods and services stable or increasing?

Are cultural institutions (for example, theaters, museums, and churches) stable or increasing in variety and number across all communities within the ecological system management unit?

Is the physical infrastructure of the communities being maintained or extended?

Is there a full suite of government services within the area of the ecological system management unit?

Does local government have a land-use planning mechanism that helps to ensure community stability?

Does the local land-use planning mechanism operate cooperatively with the ecological system management planning mechanism?

Do nongovernment organizations provide a stable or expanding suite of services to the population of the ecological system management unit?

Process Indicators

Are family monetary incomes within the ecological system management unit stable or increasing?

Is access to capital investment funds within the ecological system management unit stable or increasing?

Is the net capital monetary inflow stable or increasing?

Is the proportion of children choosing to remain in smaller communities stable or increasing?

Are people's expectations regarding the future of their communities being met?

Is access to vital forest resources stable or increasing (within the ecological systems capacity)?

Are human subsidies from outside the ecological system management unit decreasing (for example, redistribution of wealth by federal and state governments)?

Is the ratio of property value to local income stable?

Is the ratio of state and federal income tax to local tax stable?

Is the community sense of social/cultural identity stable or at a desired level?

Is consensual dispute resolution (for example, in ecological system management) stable or increasing?

Is the external institutional context of the ecological system management unit responsive to local needs?

Is there an increasing flow of information between local communities and their context beyond the ecological system management unit?