Appendix 5.2

The following material is Appendix 5.2 for Chapter 5 of: Fowler, C.W. 2009. Systemic Management: Sustainable Human Interactions with Ecosystems and the Biosphere. Oxford University Press

1 Asking management and research questions

In conventional management we force ourselves to convert information unrealistically. Consider, for example, a situation in which we knew beyond doubt that fishing caused observed declines in fur seals, sea lions, birds, and walleye pollock in the Bering Sea (directly or indirectly). This is, of course, hypothetical (science rarely fully proves anything). However, it serves to makes a point: such knowledge would do little more than further validate a principle that is already accepted. That principle is: there are interconnections and relationships between and among parts of complex systems. Interconnections are part of the complexity to be taken into account in the implementation of Management Tenet 3.

However, there is another important point. Proof that fishing is causing population declines for various species (and maybe increases in others) in the Bering Sea does not tell us how much walleye pollock to harvest each year. Human judgement might lead to the conclusion that we should reduce fishing, but by how much? Such proof would not tell us how much biomass we can sustainably remove each year from the eastern Bering Sea ecosystem, from any species within the ecosystem, or from any particular set of species (e.g., the sets defined as the resource species consumed by fur seals or sea lions).

Observed declines in populations such as fur seals, sea lions, or walleye pollock lead to posing a clear management question (or questions). What is a sustainable harvest of pollock in the eastern Bering Sea? What is a sustainable consumption of biomass in the eastern Bering Sea? If there is the remotest thought that population declines might be related to global warming or pollution: At what rate can CO_2 be produced sustainably by our species? The questions we ask must start with clear management questions. This appendix is an initial treatment of the asking of questions and the relationship between management questions and questions for research (science questions).

One management question leads to many others—all part of the experience of complexity, hierarchy, and interconnectedness, and taking them into account. When science exposes a problem, it leads to posing management questions. Any known or suspected connection between human agency and identified problems in the systems with which we interact is grounds for asking a management question. Management questions always address what we humans should do, or what we can do sustainably as humans (combining all Management Tenets, from Chapter 1, but especially 1, 2, and 9). What is sustainable in our interactions and relationships with other species, ecosystems, and the biosphere?

Management questions lead to science questions. Scientists are responsible for producing the information used in management. In systemic management, there must be an isomorphism between the science question and the management questions (there must be identical units, logical typing, and circumstances to avoid any need for conversion). There must be a one-to-one mapping between the management question and the research question it generates. Thus, the posing of a clear management question itself defines the corresponding research question. This results in science best

suited to providing the most useful information.[1] The asking of questions is where all stakeholders play a very important role (bottom row, Fig. 1.1) in leading to objective information to guide the process of setting goals and policies. The process of asking questions may be driven by politics, special agendas, emotions, economic interests, both short-term and long-term bias, personal preferences, and religious beliefs. Such factors are not the basis for management; they provide motivation for asking clear questions (an important distinction between the top row and the bottom row of Fig. 1.1). In other words, concerns expressed by anyone give rise to thinking that helps pose management questions; all questions are of very real concern to management. Once clearly posed, however, each management question specifies a research question. The resulting research leads to information that is consonant with the management question. Such information is the basis for establishing goals and policies through the implementation of Management Tenet 5. The process leads to a great deal more objectivity than is found in conventional management. The role of stakeholders (including managers and scientists) in decision making is converted from a process of converting/translating information (top row of Fig. 1.1) to that of asking good management questions paired with consonant research questions (bottom row of Fig. 1.1).

Some management questions involve components of an original question. Among these are questions related to implementation of guiding information relevant to the initial question. Still others are meta-level questions of which the original question is a component question. This appendix considers the treatment of the additional questions raised by any particular focal question—always accompanied by consonant research questions. The process of generating more management questions involves three elements: (1) asking entirely new questions, plus (2) refining, and (3) expanding related questions. The following will deal with the refinement and expansion of any given question. These correspond to accounting for lower (components or parts) and higher levels (inclusive, larger wholes or hierarchical levels) of systemic organization. The more detailed component questions include information necessary to provide guiding information for implementation. In the process, entirely new questions always arise and any question can be refined or expanded. This appendix ends with consideration of management questions at the individual level in contrast to the species-level bias of the book.

2 Refining questions

Questions important to management can be identified by breaking any one management question into component questions and taking advantage of correlative information. Component questions are crucial to implementation—finding ways to carry out the change necessary to achieve the goal established for the original question. Each question, however, occurs as part of a pair—there is always a second question related to research or observation in which guiding information is produced. The guiding information is similar to information used in navigation wherein the path (between a current location and a desired location) is established based on the experience of past trial-and-error exploration of channels and waterways—things that are observed to work.

2.1 Component questions

If we decide to harvest the population of a fish, there is more to the issue than the amount of biomass or numbers that can sustainably be removed (consumed or harvested). There are also questions regarding time, location, age, and size composition. Spatial and temporal allocation are questions to be addressed—all related to the overall question of how much of any resource can sustainably be consumed (water, energy, nitrogen). Totals are only a start toward dealing with complexity in systemic management. Asking about sustainability in the total number of resource species to consume leads to questions regarding allocation. What portion of the total harvest from the full set of resource species should be taken from each of the individual species (addressed with data on interspecific selectivity, or composition of the diet, with data such as those shown in Fig. 2.8)?

Component questions are particularly important for guidance on methodology—the how of

management. Here, as in navigation, the path must be specified after attaining information on the goal and current location. The specifics of implementation involve components. In fisheries management, these involve such things as choice of gear, mesh size, time of day, net type—complexity again, but now involving and relying more on patterns of direct human experience. The legal and regulatory details are also to be established on the basis of years of experience in finding ways that work.

2.2 Correlative information

The matter of using correlative relationships was considered in this chapter (and Chapters 2–4) as one of the four ways in which complexity is taken into account in systemic management. This is a matter of directly (or overtly) accounting for such things as human characteristics (e.g., body size, metabolic rate, trophic level), factors we decide to ignore (e.g., the decision to take adult fish in a fishery when most other species take juveniles), and environmental factors (e.g., mean temperature, climatic variation, and other environmental circumstances) when the information is available. Statistically, this is a matter of breaking down the overall variation into its components by accounting for "explanatory" correlations (e.g., see Fig. 2.31 wherein the overall variation in population density is partially "explained" by body size).

Correlative information is brought to bear in the refinement of management questions, some of which were exemplified in Chapter 2. So, rather than stopping at a simple question (such as: "What is a sustainable harvest of individual fish stocks in the eastern Bering Sea?"), refinement results in dealing with more complexity (directly) by asking more detailed questions (such as: "What is a sustainable harvest of individual fish stocks characterized by the adult body size of walleye pollock in the eastern Bering Sea?"). Here is where relevant information is involved in a different kind of conversion from that of conventional management. Rather than letting stakeholders interpret such information, it is used as correlative identification of the most useful consonant information. The correlative variables are integral parts of the overall patterns used in management.

2.3 Implementation

Having an objective in mind requires information about how to achieve it. If the sustainable harvest of fish from a marine ecosystem can be established as outlined in this book, then there is the matter of how to implement management. Past experience in management is invaluable. Laws and regulations can be established, enforcement can be carried out, management councils can function, and fishermen can operate as they have learned to operate in the past. If protected areas, closed season, or single resource species quotas are established with systemic information, these objectives become matters to be achieved through practices we recognize as proven options for implementation. Many of the mini-objectives of implementation become a matter of systemic management based on the variety of human experiences whether they involve individuals, industry, government, or society. In at least some cases, the challenge is less a matter of how to carry out the management than it is that of achieving objectives that have been identified—confining ourselves to workable limits. This always involves more expansive questions in regard to more inclusive systems such as ecosystems and the biosphere.

3 Expanding questions

Refining questions is not enough to deal with complexity. It is crucial that we also *expand* questions. Through expansion we account for ecosystems and the biosphere among the levels of biological organization that include humans as a component. Humans interact with, and influence, all systems of which we are a part. Thus, we can start by asking what the sustainable level of harvest from walleye pollock might be. However, we must also be guided by answers to questions such as "Should we harvest walleye pollock at all; should pollock be among the species that we harvest?" Predators in an ecosystem do not consume from all species in the ecosystem. The harvest of pollock is part of the total harvest for an ecosystem, and abnormality must be avoided in the total harvest from an ecosystem? Abnormality must also be avoided in the numbers of species which we harvest. Here, we

confront the management question of how many species we should harvest: "What is the total number of species that can be sustainably harvested?". This question is added to those regarding the allocation of harvest across alternative species (Fowler 1999), the geographic range over which harvests are taken, the total take and allocation across tropic levels, and the allocation of take over seasons. Expanding the scope of inquiry, like refining, generates an unending list of questions (i.e., again humanly inexhaustible). Further expansion involves harvests at the level of the biosphere. Harvesting fish in the Bering Sea is part of the total consumption by humans in the biosphere and opens the door to even more questions, all of which are part of systemic management. Again, we face human limits and deal with information we have in hand. This is done while we obtain further, more consonant, information with more research for pressing questions for which we lack consonant information. We continue with the responsibility of developing as many questions as possible. Known questions for which we lack consonant information is basis for research—a great deal of research.

At every step, asking the research question that is consonant with each management question is of crucial importance. Thus, when the management question is: "What is a sustainable harvest of five-year-old walleye pollock in the eastern Bering Sea during summer months?", the consonant research question is: "What is the consumption rate of five-year-old walleye pollock in the eastern Bering Sea during summer months for marine mammals of human body size?" Consonance is achieved in addressing consumption, a specific age-class of walleye pollock, identifying walleye pollock (with all of its characteristics), specifying location and season, and recognizing the taxonomy and body size of the predator (humans). In all cases, species are part of the consonance; humans (about which the management question is being asked) and marine mammals (the empirically observed examples of sustainability). As mentioned earlier, with the results of such research, no further translation, interpretation, or combination of information is required in establishing goals after adhering to Management Tenet 5. Setting goals this way removes the vulnerability of the decision-making process to the effects of politics, economic factors, emotions, human limitations, bias, hubris, arrogance, or other human qualities. These play their role in leading to meaningful management questions, followed by consonant research questions, consonant research, and consonant action (bottom row Fig. 1.1).

In addressing questions regarding things that other species do not do, both component and expanded questions are particularly important. For example, we face the question of how many computers to produce (or at what rate to produce them). First we face the fact that other species produce no computers—information. If we decide to produce computers anyway, it is important to address component questions exemplified by energy consumption, use of individual materials (copper, mercury, silicon, petroleum, etc.), waste production, and temporal allocation of human activities that are affected by the use of computers. What portion of each 24-hour day can sustainably be spent in activities devoid of interaction with other species and open air? What portion of each 24-hour day can sustainably be spent devoid of the aesthetic qualities of nature, gathering food, resting, interacting with other humans, witnessing the risks of nature, or sitting versus walking/running?

4 Questions at the individual level

This section addresses questions applicable to us as individuals to help provide insight regarding the asking of management questions that lead to research—all in the practice of producing scientific information best suited for management.

The field of ecopsychology has raised concerns about our "disconnect" with nature (actually abnormal relationships with other elements of nature because we cannot be seen as anything but a part of reality). These concerns can be used as motivation for specific management questions.

For example, "What portion of the day should we be spending in procuring food?" Research in response to this question would involve individuals in other cultures, conducted to find the allocation of time for various activities, including that of finding, harvesting, and preparing food. Information from ancient and long-standing cultures would be

evidence of what works. However, research would not be confined to humans and would include individuals of other species so that consistency would be achieved at all levels. The research questions would be: "What portion of the day is spent procuring food by individuals in other cultures and other mammalian species of our body size?" Such research would provide objective scientific information to illustrate the abnormality of modern western cultural human life at the individual level—most of the production, distribution, and acquisition of food is industrial. Individuals in such cultures spend very little time during which the experience of hunting and gathering provide them with first-hand ecological insight, spiritual connection with other species, and a sense of limits set by ecological systems.

A related question involves the diversity of species in our immediate surroundings. Here, the abnormal relationships we have achieved in modern civilized cultures often involves city dwelling, life confined largely to time spent living in rooms, or surrounded by monocultures of commercially valuable species. What would be a normal diversity of species in our environment with increasing distance from each of us as individuals? Again, research would involve indigenous cultures, and include other species. The research questions would be: What is the pattern in diversity of species in the environment of individuals, expressed as a function of distance? Various measures provide options, including the simple count of species included in an expanding circle or sphere around individuals. The relative lack of other species in the immediate surroundings of people in civilized cultures would become apparent; most other species and many individuals of indigenous cultures would show a much higher diversity of species within 100 meters than westernized humans. Core to the concerns of ecopsychology is the psychological effect of this lack of diversity.

The list of questions of the kind introduced above is again an endless expression of complexity. What is a normal average distance to the nearest individual of a nonhuman species of human body size? What is the pattern in average distance to individuals of other species as a function of body size? With a multitude of other species within one's field of vision on a more continuous basis, the world-view of people of civilized cultures would be entirely different; our values would be different, our mental state would be different, we would almost undoubtedly feel more of a sense of well being.

The field of medicine also raises concerns; exercise has been recognized as important to physiological, physical, and emotional health. What is a normal distance traveled in a lifetime? What is the pattern in lifetime distance traveled for mammalian species of human body size? How much energy should be spent in exercise? What is the pattern in energy spent in exercise for individuals among mammalian species of our body size? What portion of the average day should be spent getting exercise? What is the pattern in portion of time spent in exercise for individuals in mammalian species of our body size? How much exercise should be achieved at various pulse rates? Within each day, what is the pattern of time spent with the heart beating at various rates for individuals of nonhuman mammalian species of our body size? What portion of one's life should be spent in getting exercise on machines, sidewalks, swimming pools, or pavement? What is the pattern in portion of exercise experienced on soil or rock, in lakes or rivers, and in proximity to a diversity of other species when measured for other mammalian species of our body size?

Other fields of science (e.g., evolutionary ecology, outdoor recreation, and the behavioral sciences) can be the source of questions similar to those exemplified above—both for us as a species and for us as individuals. Agricultural scientists can ask: What would the normal diversity of species be where we now have monocultures of corn, rice, wheat, and other agricultural crops? Research can be conducted to take advantage of the few remaining spots of seminatural grasslands to begin to find the patterns consonant with such questions. Others can ask: What is a sustainable population size for cattle, sheep, hogs, goats, chickens, or turkeys? Research to reveal patterns similar to that shown in Figure 5.1 can be conducted to answer the question for each species (i.e., with data for mammalian or avian species of similar body size).

It is the responsibility of scientists to both help ask such questions and then to conduct the science to reveal patterns that differentiate the normal and abnormal so that answers to management questions are produced with information that needs no conversion.

Note

1. The matter of providing the best scientific information for management has long been debated, and often involves consideration of the quality of science rather than the choice of information. Thus, we are often left with guidelines for producing such information rather than a clear definition of what the best information is (NRC 2004). Part of what systemic management accomplishes is a clear definition of the scientific information best suited for management. It is information consonant with the management question. In conventional management there is a form of alchemy involved in converting a mixture of nonconsonant, fragmented, and incomplete information to answers to management questions (usually ill-defined questions if they are asked at all, top row of Fig. 1.1). In systemic management consonance between empirical pattern and management question means that there is no need for conversion; the best scientific information prevents the need for conversion. The quality of science is still a factor and it is essential that good science be brought to bear, but the choice of information that good science produces is the key factor in the definition of best scientific information available for management. It involves the clear distinction between relevance and consonance. Confined to mere relevance we cannot help but make errors; consonance serves us well when expressed in terms of variation that serves to identify the abnormal.

References

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