Introduction

Improving the health of people and animals as well as improving the health, integrity and sustainability of ecosystems are both laudable and important activities. Can we do both? Clearly, if we wish to have health in the future, then the integrity of ecosystems, which make our lives possible, is relevant. To say we can have sustainable population health without sustainable ecosystems is like saying that we can have a sustainable, healthy heart without a sustainable body, which gives it life and meaning. Yet linking health and ecosystems grammatically – a common and generally well-received notion these days – will do little to link them in real life. Some people would argue that the only ecosystem with integrity is one with no people in it. These people seldom use the word health because they think that health involves value judgements, and integrity is value-free. If anything, integrity is more value-laden, and indeed legally moralistic (which is why it attracts some environmental regulators), than health. Nature may well be value-free, but there is no way to evaluate our status in nature, or to talk about progress, without reference to values. It seems best to some of us to accept this and try to deal with it head-on. There are, quite frankly, no ecosystems that do not, in one way or another, bear the imprint of human meddling.

Conversely, it is possible to achieve population health, at least in the short run of a few hundred years, by radically restructuring and perhaps endangering ecosystems. People of European descent have done this for decades – draining swamps, chlorinating and diverting waterways, cutting down dark and dangerous forests and replacing them with carefully tended crops or regimented tree plantations. We now have improving indicators of human health world-wide, largely as a result of this strategy. We also have worrisome signs that the world's ecosystems may be at the limits of their ability to adapt to this radical restructuring. As I consider the losses of our fellow species on this planet, I wonder if the improvements in health come at the expense of an impoverishment of well-being.

Between these two extremes, a body of theory and practice has developed. While acknowledging the tensions between the health and well-being of the various species with whom we share the planet and the ecosystems which nurture and give us life, this new field of inquiry also seeks to find the interactive, relational space that is our common future. Converging from disciplinary bases as diverse as epidemiology and participatory action research, philosophy and environmental sciences, ecology and systems sciences, a new, integrative, place-based science for sustainability, or post-normal science as Funtowicz and Ravtez have dubbed it, has emerged. In this fertile and hopeful ground, a new kind of practice is taking shape.

Much has been written in the scholarly literature about the intellectual basis for this new science. These theoretical developments provide the basis for a generalization of sustainable action. However, the specifics of what form that action might take, especially for health practitioners, have yet to be brought together in a coherent way. Just as medical diagnostic techniques are not the same as those used for health promotion, the methodologies used to *understand* the ecosystems in which we live may be inappropriate for *promoting* ecosystem health. Without the right tools, many practitioners simply fall back on the same old toolbox. We have a thermometer, so the problem must be temperature. Where's the rectum? We have a net, so the problem must be fish. Where is the river? We have data on income. Therefore the problem must be economic. Where is the mathematical model? The point is not that measuring temperatures, fish populations, or incomes is unnecessary but that they only acquire meaning in context – and people will only act upon information which they think is meaningful. Furthermore, if we want to promote realistic national and international policies, then we need to have some idea of what might actually get us where we want to go. Moral umbrage can only get us so far – and often in the wrong direction.

This book is about searching for solutions to complex problems. The health, agricultural and ecological problems we face in the year 2004 are qualitatively different to the problems for which standard scientific, medical and political tools and programs were designed. Given the messy nature of the dilemmas and contradictions facing us, there can be no single recipe, and no definitive set of tools. However, some approaches, ways of thinking and ways of doing seem to be more useful than others. The ecosystem approach, as defined and used by researchers and managers of the International Joint Commission within the Great Lakes Basin, is one such approach (Allen *et al.* 1993; Kay *et al.* 1999). Grounded theoretically in complex systems, and practically in participatory research and adaptive management, the ecosystem approach is a way of working with people in such a way that measurements are given meaning by understanding their context, or rather, that both measurements and action emerge from the context.

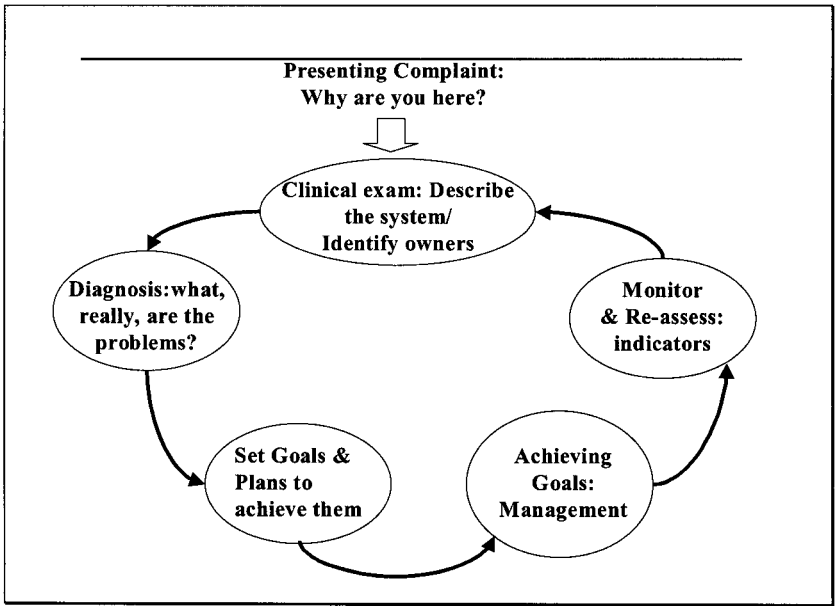

Figure 1 The Basic Figure: a medically based assessment and treatment process.

This book is designed primarily for use by practitioners, that is, those who wish to understand and improve – in a sustainable fashion – human, animal and ecosystem health. This certainly includes health practitioners – veterinarians, physicians, nurses and public health workers. It will also be of use for those in fields such as agriculture, environmental management, wildlife biology, city planning, food safety and international development, who are working alongside health workers in addressing these complex problems.

Just as there are many ways to describe the complex reality in which we live, there are many ways to describe the process of assessing and improving the systems of which we are a part, and this text will present a selection of those. None of them by itself captures the whole complexity either of the system or of the process. Because this text is addressed to health practitioners (in a broad sense), the health management process, as outlined in Figure 1, which I shall refer to throughout the book as the Basic Figure, serves as a useful starting point. Although it will lead us in some significantly new directions, and will in fact undermine itself to the point that we must conclude that medical approaches are not only inadequate but counterproductive, this process begins in what hopefully is familiar territory for health practitioners. It draws on the medical diagnostic process and the herd health management model used by veterinarians when assessing the health of groups of farm animals.

This process was originally designed for examining and treating individual people or animals. Someone comes into a doctor's office with a presenting complaint – a headache, perhaps, or a fever. Or a farmer calls the vet because her cow is not eating. Or a father visits a community health nurse because the baby won't stop crying. Once the patient or client is through the door and has had a chance to express his or her complaint, there follows a clinical examination of the patient, a diagnosis of what the problem is, some suggestions as to what might be done about it, and then some actions and follow-up. At the farm-animal herd level, the principles are basically the same, except that the presenting complaints may have to do with low reproductive rates or poor growth rates, and economic (making enough money) and social (having time to spend the money) considerations begin to get mixed into the goal-setting. Once we begin talking about ecosystems and communities, the problems get even more complicated – indeed they get (in technical terms) complex. That is, they resist understanding by any single method or set of methods.

These complications of the basic diagnostic and treatment process alter, in some fundamental ways, our understanding of disease and health, and the skills required to prevent one and promote the other. In a standard diagnostic or herd health management process, there would be little discussion about who the owners are, and we are usually taught that the nature of the problem is somewhat independent of who defines it. A reproductive or disease problem – so many people believe – is a problem no matter what the owner thinks. This is actually false, which has led to many of the battles between, say, European farmers and American drug companies about what constitutes improvement in animal health. When we are tackling ecosystem health, the nature of the problems and the ownership of the system interact even more closely than they do at herd level; in fact, ecosystems have many owners, not all of them human, and what some of the owners see as problems, others see as solutions. This is why, in the Basic Figure, the description of the system (which comes from the clinical exam) and the identification of owners appear in the same circle. Ultimately, we will also move to an understanding that there are close relationships among the diagnosis, the description, and ownership. These considerations lead us beyond basic disciplinary science to a kind of public, integrated, contextual science in which the various actors and owners are part of the process of generating knowledge and critically evaluating it. In many ways, this has much more in common with Paulo Freire's 'problem-posing' within a total context than it does with conventional academic and business science. The main differences between Freire's action-education and the ecosystem approach is that the latter is explicitly rooted in complex systems and ecological perspectives, as set out by Kay *et al.* (1999).

Despite all the complications, however, the underlying processes of assessment, goal-setting, action and reassessment (monitoring) hold true. If you get lost in the forest of complications in the chapters that follow, it might be useful, periodically,

to refer back to the Basic Figure. Once we have worked through the entire process, I will (in Chapter 6) present a revised version, the Adaptive Methodology for Ecosystem Sustainability and Health (AMESH), which incorporates our new understanding of complex systems, eco-social change, and how human communities can live sustainably and convivially on the planet. James Kay, Tamsyn Murray, Cynthia Neudoerffer, myself and several others have developed AMESH and tested it in ecosystem health-type projects around the world. It is our hope that AMESH will become the new starting point, the new baseline, for investigating and resolving the complex problems presented to us by communities and the ecosystems of which they are integral members.

An earlier version of this book was titled 'Ultimate Patients'. For reasons of clarity in marketing, the title was dropped, but I think it is worth reminding ourselves that the eco-social systems, of which we are a part, are the 'ultimate patients' whose pathologies we seek to limit, and whose health we seek to promote. We also need, in the midst of the urgent agendas besieging us, to find ways to 'think like ecosystems', to develop a kind of 'ultimate patience'. One approach to the catastrophic ecological changes occurring around the world is to panic, rushing into Draconian, undemocratic measures. These will surely backfire. Another is to take a more measured, deliberate, directed approach, perhaps like a veterinarian or physician in an emergency. There are important things we need to do but the level of uncertainty and the stakes are so high that rushing is unlikely to improve the situation, and may well make it worse. In ecosystem health, as in animal and human health, our first aim is to do no harm. I hope this book can contribute to achieving that goal.

1

Presenting complaint

Within any health profession, we begin to examine a person, animal, community or ecosystem when we have some inkling that something might be amiss. Usually, someone comes to the practitioner with a complaint: the animal has diarrhoea, the person is having trouble breathing, the water smells funny, there are dead ducks along the shoreline. This is called the 'presenting complaint'. Certain symptoms and signs characterize this complaint. Symptoms are what a person or animal feels (headaches, depression); signs are what can be measured (temperature, heart rate, dead bodies). We tend to think that a dysfunctional ecosystem might have signs but no symptoms; however, ecosystem ill-health may be manifest by symptoms in the people and animals living there. For instance, poet Leonard Cohen captured the feeling of dis-ease between external events and internal feelings in one of his songs when he said it 'looks like freedom but it feels like death'. In general, presenting complaints have to do with symptoms, and practitioner responses have to do with signs. This book will tend to focus on signs, but the process we finally arrive at in Chapter 6 is designed to improve symptoms as well.

What are the clinical signs?

While those who are primarily concerned with environmental management might struggle with the need to find a coherent framework within which to define, evaluate and promote 'progress', we might ask why health practitioners need to be bothered with this. Don't we already have a successful global medical and health enterprise, suffering perhaps from under-funding, but, where money is available, bringing longer and healthier lives to everyone? Do we have any evidence that something might be wrong?

The answer to this question is more complex than it appears at first glance. While disease management and mortality prevention have been very successful in the latter half of the twentieth century, we are beginning to see signs that this success, and

success in other fields of human endeavour such as agriculture, is actually creating serious new problems. The signs we are seeing may be early warnings that we are pushing the world's ecosystems to the limits of their capacity to absorb human impacts. A. J. McMichael discusses these in his book, *Planetary Overload: Global Environmental Change and the Health of the Human Species* (1993). Even if this is not the case – even in the most Pollyanna, the-world-is-okay scenario – the signs we are seeing indicate problems that are serious in their own right, and worth addressing.

Initially, we start with a list of the kinds of signs that, we believe, reflect systemic problems. Some of these are clearly at a particular scale (it's hard to see a hole in the ozone layer as a local problem), while others could be at any or all scales (species loss, for instance). Here is a starter list:

hole in the ozone layer
soil erosion
resistance of insect vectors to pesticides
loss of non-target insect species
loss of non-target birds and mammals as a result of attacking disease vectors
frogs dying
chemical spills
trees dying
acidification of lake water
dead, disappearing or deformed fish, dolphins, seals . . .
people getting sick or dying
contamination of drinking well or tap water
increases in the size, number and nature of foodborne diseases
West Nile virus outbreaks
Hantavirus outbreaks
floods/ droughts/ sudden rainfalls/ more storms or hurricanes (sudden weather events).
antibiotic resistance in microbial populations
irrigated soils become too salty to use
epidemics of malaria, obesity, starvation . . .
vultures dying in India
botulism epidemics in Merganser ducks on Lake Erie

The list, of course, is almost endless. Given such a list – which in any given context will be finite and limited – how can we begin to work our way from these signs back to the shape and size of the patients we are dealing with?

The first step is to organize the signs into some sort of coherent framework. Some signs pertain to particular spatial scales of system. Water-related problems (contamination, scarcity), for instance, may indicate ecosystem stress or dysfunction at a watershed level. Epidemics of disease are characteristics of populations. Floods and droughts might be related to regional climate changes.

Some signs actually reflect the context for others. Thus, water contamination with pathogens might be a sign of an ecosystem problem in its own right, but may also be seen as a contextual risk factor for human diarrhoea. Disease epidemics may occur because particular wetlands dry up, which may reflect global climate change. So, we might focus on one scale, but quickly find ourselves moving between scales for causal variables (larger scale) or explanations of process (smaller scale).

Another way to organize the signs is by system. Thus we might look at the water system (hydrological cycles), food system (food webs, agrifood system organization), nitrogen cycle, and so on. We might also consider various kinds of pathology: dysfunctions characterized by broken feedback loops (farmers producing for markets without regard for their natural resource base), or unresolved conflicts between an invasive species and the long-term inhabitants (people versus old growth forest, for instance). This way of organizing signs requires greater knowledge of a situation than we might have when we start. Thus, classification by pathology is often retrospective (or, if it is too early, it becomes a sort of pathological classification, creating problems by the way it structures the situation; declaring water contamination to be a water system problem opens some doors to possible solutions but closes others, such as agro-ecosystem management). On the other hand, we know a lot about many of the problems we are dealing with, and an *a priori* classification can help us look for patterns. Only be aware that the classification is a human construct – useful but dangerous.

For some situations we already have sufficient understanding to group clinical signs into broad diagnostic categories. At this point in the eco-health process, these must be seen as tentative diagnoses to guide further in-depth investigations in the pursuit of something more definitive. At least five such systemic diagnostic categories can be created for framing our thinking about emerging infectious diseases.

1. Disease treatments don't work

Many disease-control programs are no longer effective. In fact, one could argue that disease treatments are causing disease. Microorganism and parasite populations are rapidly developing resistance to a wide array of antibiotics and pesticides. Both the range of drugs to which these organisms are resistant, and the proportion of organisms that are resistant, are increasing. This rising tide, globally, of multi-resistant organisms and pesticide-resistant insect vectors is the direct, unintended, result of therapies we use to control or eliminate them. One short-term response to these 'counter-attacks' is simply more of the same – more vaccines, more drugs, more pesticides. In some ways, this is like responding to successful guerilla warfare by proposing bigger conventional armies and weapons. I suggest that it is time to ponder the wisdom of our bio-military metaphors and linear causal thinking, to

address the flaws in reasoning and tactics we have employed to date, and to use our much vaunted intelligence as a species to find more creative solutions.

2. Health promotion causes disease

Success in programs which manifestly promote health in some dimensions – such as improvements in agriculture to address food shortages – have had unintended negative effects on other aspects of health, such as disease. Talking about creating 'supportive environments for health' is simplistic. It would be possible to create a large mall that is supportive to health (filtered air, lots of food, exercise gymnasiums, music). In a sense, industrialized countries have created a healthy 'mall' by externalizing costs to the poor and vulnerable. Some water management programs have had devastating effects by favouring several tropical diseases. Dams are built to generate electrical power, to control flooding, and to generate wealth (all of which are demonstrably supportive of health). Nevertheless, they also expand or create new habitats for flora and fauna which cause disease, and remove sources of natural renewal from farmland (Hunter *et al.*, 1982). In Bangladesh, epidemic Kala-azar (leishmaniasis) has occurred in populations living within flood control embankments (Minkin *et al.*, 1996), and malaria epidemics, 'mad cow disease' and cyclosporiasis have all been associated with aggressive agricultural programs (Waltner-Toews, 1999). Improving the outdoor environment by providing trails and parks, and encouraging people to use them, has resulted in improved physical and mental health in those members of the population who can avail themselves of these amenities. However, these same activities are associated with an increase in a range of diseases such as Lyme disease and West Nile virus infection.

If increasing populations of ducks by creating artificial wetlands can be seen as improving population health (in a Darwinian sense it's at least increasing survival), then the millions of ducks that die each year of botulism in those artificial wetlands can be seen as victims of a disease caused by a health program. On one of our field trips as part of the veterinary Ecosystem Health Elective, we studied one wetland where more ducks died than were born – a nursery turned, in a kind of Stephen King twist of plot, into a mortality sink.

3. Disease control causes disease

Same scale

How can disease control cause disease? This is most obvious in food-borne diseases, where industrialization and centralization, which quite naturally accompanied regulations on canning and pasteurization to control botulism and brucellosis,

have been associated with large-scale epidemics of diseases like salmonellosis. This is because the consolidated system has larger ecological niches for bacteria (more cows in one place, more volume of milk mixing) and longer transport distances. Imposition of food safety programs developed in industrialized countries with good, expensive, energy intensive infrastructure, on poor southern countries with bad roads and unreliable power sources will likely worsen the situation considerably rather than improve it. A study of small-holder dairying in Kenya by Amos Omore of the International Livestock Research Institute, for instance, suggested that the best way to ensure a safe supply of milk was to encourage the widespread practice of boiling milk, and support hygiene programs for small producers, rather than promoting centralized pasteurization plants. In North America, policies and practices which encourage a voluminous and cheap supply of food serve, on the one hand, as a preventive against starvation. On the other hand, they also undercut the economic and ecological sustainability of farmers, and are associated with a whole new array of nutritional and disease problems associated with obesity.

Cross scale

Current health and disease control programs often work against each other across organizational scales. Problems are solved at an individual level but become major problems at a regional or global level. Thus, saving children through vaccination without concomitant programs in education, nutrition, agriculture and sustainable livelihoods undermines the health of whole communities and condemns them to slow and painful death and disintegration (McMichael, 1993). Indeed, the tension between sustainable population health, which requires a certain death and replacement rate, and individual health, for which death is the ultimate negative outcome, has no solution within current biomedical models (Waltner-Toews, 2000a). The idea that death and maybe even disease might in some sense be important for sustainable health cannot even be conceptualized in a normal biomedical framework.

At a more mundane level, we have the absurdity of governments in some industrialized countries giving away groundwater to private companies, who then wrap it in plastic, sell it back to the original owners of the water (the citizens of the country) under the pretence that this is good for their individual health. Even if the water in the bottle could be demonstrated to be superior to tap water, it would still have major negative consequences for population health because of the energy and resources required for manufacture and disposal of the bottles.

Drawing inferences about populations based on studies of individuals is termed the atomistic fallacy, and is widespread and widely tolerated in epidemiological studies. Ironically, the converse fallacy – drawing inferences about individuals from population studies – is vigorously guarded against. What this means is that all efforts are focused on finding individual determinants of disease, and the broad systemic