FEATURE

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APPLYING SYSTEM DYNAMICS TO PUBLIC POLICY: THE LEGACY OF BARRY RICHMOND

BY STEVE PETERSON

System dynamicist Barry Richmond was one of those larger-than-life characters whom one seldom encounters in this world. His incisive intellect, passion for building understanding, gifts as a teacher and communicator, boundless energy, charisma, and intellectual curiosity put him in a class by himself. For those of us who counted Barry as a colleague, collaborator, or friend, his passing in August of 2002 created a huge gap in our lives, a gap that will not soon be filled.

Barry's death left a gap in the field of system dynamics as well. As the founder of High Performance Systems (now isee systems) and the driving force behind the popular *ithink*® and STELLA® systems thinking–based software products, he made computer modeling accessible to people in business and education. At his memorial service, several speakers commented on what Barry's life had meant to them. Peter Senge spoke about both the importance and the incompleteness of Barry's work, noting that it was "up to us" to continue this important effort.

Since Barry's death, I have spent a lot of time reflecting on his life and contribution to the field of system dynamics. In this article, I identify five operating principles that guided Barry's work, especially in the realm of public policy. These principles are also applicable in business, education, and other areas of inquiry. By way of summary, I also offer a few thoughts about the nature of Barry's legacy and how we might build on that legacy.

A Broad-Brush Conceptual Framework

To gain a deep understanding of Barry's work, it is first necessary to have some sense for where he was coming from. What motivated his activities? What were his ideas regarding the real value of system dynamics?

Fortunately, Barry left a good paper trail that documents his thinking. For example, the STELLA and *ithink* user guides (HPS, 2003) do an excellent job of presenting Barry's view on how to "do" system dynamics. In *The "Thinking" in Systems Thinking: Seven Essential Skills* (Pegasus Communications, 2000), Barry identified the key competencies behind the effective practice of systems thinking.

"The framework, tools, and language of system dynamics should be accessible to all. Anyone can do this at some level, and everyone should try!"

These resources shed light on Barry's fundamental belief, which provided the motivating force for many of his professional endeavors. I like to phrase it this way:

"The framework, tools, and language of system dynamics should be accessible to all. Anyone can do this at some level, and everyone should try!"

This belief is an assertion that the primary value of system dynamics comes from the process not the products of that process (although Barry would readily agree that products were important, too!). It's also an assertion that as more people use the framework, language, and tools of systems thinking and system dynamics to generate insight—and act accordingly—the more likely we will be to solve the big problems facing the world today.

Over the time that I collaborated with Barry, this deeply held assumption was never very far out of sight. It would often come to the surface in the context of a formal presentation, essay, or paper. Consider, for example, Barry's contribution to the 1985 System Dynamics conference in Keystone, Colorado, in which he introduced the STELLA software. The paper he presented was entitled "STELLA: Software for Bringing System Dynamics to the Other 98%." The title clearly reflects Barry's fundamental belief that everyone should be using these tools.

Or consider the paper Barry presented at the 1994 conference in Sterling, Scotland, provocatively titled, "System Dynamics/Systems Thinking: Let's Just Get On With It." In the paper, Barry asserts that system dynamics is "quite unique, quite powerful, and quite broadly useful as a way of thinking and/or learning. It's also capable of being quite transparent—leveraging the way we learn biology, manage our businesses, or run our personal lives."

Barry devoted a huge part of his life to turning this deeply held belief into reality, through a variety of products and services, including software, learning environments, workshops, and specific client deliverables. The common theme in these efforts was increasing the base of people who could partake in the process of gaining value by doing system dynamics.

A simple graphic that Barry and I developed for use in our workshops gives a clear picture of what he saw as

the relative value of investing in various levels of analysis (see "The Return on Investment of System Dynamics").

It relates effort or time expended to the value or utility that one can expect to derive from that effort. As the curve shows, there is significant value to be gained from simple "conversational" uses of the fundamental thinking skills. Examples would include drawing a behavior over time graph to cast a problem in dynamic terms, characterizing an issue in generic terms in order to recognize patterns over time, or asking operational questions such as "how does this work?" (For details about the different systems thinking and system dynamics tools referenced in this article, go to www.pegasuscom.com/lrnmore.html and click on a term or topic.)

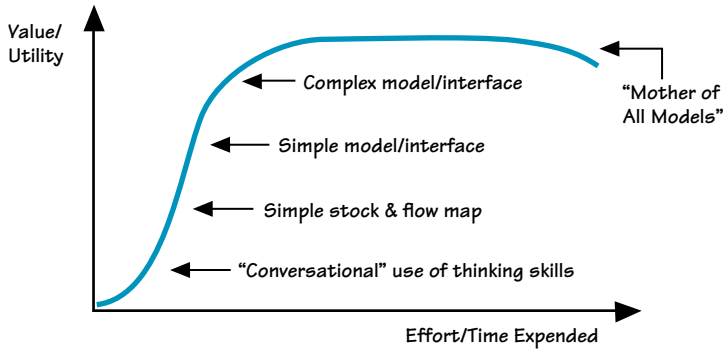
Another jump in value/utility can come at relatively low cost from creating a simple stock and flow map. A third increase in value can be added, again at relatively low cost in terms of time or effort, by transforming a map into a computer-based simulation model, perhaps with a simple interface to facilitate controlled experimentation.

Note that, once you move past simpler applications, diminishing returns can quickly begin to set in. In our experience, as the complexity of the model increases, the amount of effort, skill, and time required to underwrite that complexity increases disproportionately relative to the amount of value derived! Out at the end of the curve, adding complexity may well result in negative returns. The implication: You don't need to build huge, complex models in order to derive value. Simple, straightforward uses of the framework, language and tools can add significant value at relatively low investment!

Five Principles

This section distills what I believe are key principles that guided Barry's public policy efforts. The principles fall into three broad categories, associated with the three activities that Barry viewed as fundamental to any modeling effort:

THE RETURN ON INVESTMENT OF SYSTEM DYNAMICS



There is significant value to be gained at relatively low cost from the application of basic system dynamics skills. Once you move past simpler applications, diminishing returns can quickly set in. As the complexity of the model increases, the amount of effort, skill, and time required to underwrite that complexity increases disproportionately relative to the amount of value derived!

Building

1. The Principle of Operational Thinking
2. The Principle of Irreducible Essence

Simulating

3. The Principle of Controlled Experimentation

Communicating

4. The Principle of Mental Model Confrontation
5. The Principle of Controversial Topics

1. The Principle of Operational Thinking This principle was at the bedrock of Barry's work. Barry himself viewed operational thinking as the key thinking skill required for the effective application of system dynamics.

Operational thinking entails getting to the essence of how a process works. It involves asking questions about key accumulations, or stocks, and flows in the system. For example, "What is being produced?" "How is this activity generated?" "What resources are consumed in the process of generating the flow?" These are questions about the physical relationships among different parts of a dynamics system that work together to determine its dynamic behavior. The effort is one of building understanding of how it works rather than simply listing the factors that influence the process.

The benefit of operational thinking is that it facilitates the identification of levers for changing system performance. If you have a clear picture of how the process works, you are in a solid position to ask focused questions about alternate proposed policy interventions and more accurately think through the implications of a proposed initiative. If, on the other hand, your thinking simply results in a laundry list of factors that influence the process, your efforts to identify levers for actually changing performance may well be limited.

Barry used an excellent illustration of operational thinking in his presentation at the 2001 Pegasus Conference. This event took place shortly after the September 11 terrorist attacks. Issues associated with international terrorism were very much on the minds of participants at the conference. One part of a storytelling progression within Barry's presentation is shown in "The Inflows and Outflows of Terrorism" on p. 4.

This stock and flow map nicely captures the essence of the processes through which people become terrorists, and through which terrorist activity is generated. Note the salient features:

• The number of terrorists is represented by a stock; terrorist activity is represented as a flow. From this map, you can identify two fundamental ways to reduce terrorist activity: Either reduce the number of terrorists

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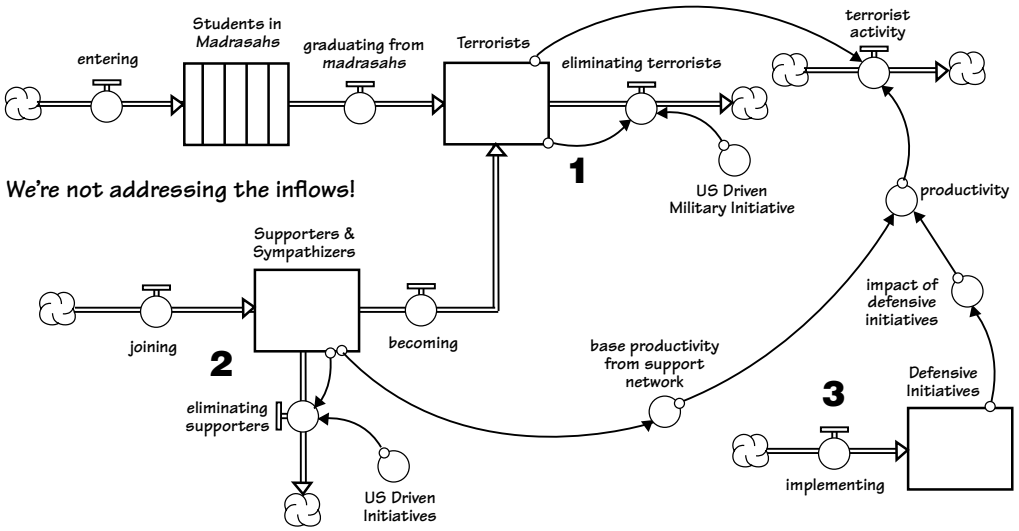
THE INFLOWS AND OUTFLOWS OF TERRORISM



The diagram captures both the inflows and the outflows to the terrorist stock; that is, the factors that lead people to become terrorists as well as those that cause them to stop their activities. In so doing, it identifies the levers for long-term improvement in the performance of the system.

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or make terrorists less productive.

- The options for directly attacking the problem are clearly mapped (eliminating terrorists, eliminating supporters, and implementing defensive initiatives).
- The diagram captures both the inflows and the outflows to the terrorist stock; that is, the factors that lead people to become terrorists as well as those that cause them to stop their activities. In so doing, it identifies the levers for long-term improvement in the performance of the system.

2. The Principle of Irreducible Essence This principle is a variation of "Keep it simple, stupid." Einstein worded this tenet as: "A good explanation is one that is as simple as possible, but not simpler." Occam's razor is another version: "A simple explanation is to be favored over a more complex one." These views, along with the principle of irreducible essence, recognize that we must simplify in order to make sense of the world—it's impossible to hold all the relationships that exist in our heads. The challenge is to preserve the relevant essence of that part of the world upon which we wish to act in our models.

The usefulness of this principle is twofold. First, it enforces a mental discipline that can lead to improved clarity about an issue. Second, irreducible essence leads to explanations that are accessible to both experts and non-experts on a given topic. As a result, following this principle can lead to a significantly larger audience of people who can derive value from the effort.

Barry's "Stories of the Month," published on the HPS web site 2001–2003, provided many examples of the principle of irreducible essence in practice. These stories typically used a simple stock and flow map or a small simulation model to provide a systems perspective on current events in the news. A story that Barry was working on at the time of his death, entitled "Hot Air and Greenhouse Gases," was motivated by some sloppy statements about global warming coming out of the White House in the summer of 2002. Among other things, these statements contended that the president had a plan that would reduce greenhouse emissions while sustaining economic growth. The implicit claim was that this plan would result in a reversal of global warming trends.

In response to these statements, Barry could have developed an elaborate model of greenhouse gases, or he could have pointed people to large, detailed models produced by others on the topic. Instead, he began working on a simple model and story (see "Growth, Gases, and Warming").

This diagram is stark in its simplicity. It provides just enough of the relevant essence of the issue to get at the dynamics of the greenhouse effect. It includes just enough structure to facilitate investigation of the interaction between reduced greenhouse emissions (for example, through "green technology") and increases in the level of economic activity that serves as the base for generating greenhouse emissions.

3. The Principle of Controlled Experimentation The principle of controlled experimentation entails making changes in a model one at a time to learn why it behaves in a particular way under particular conditions. Through such controlled experiments, users build understanding of the connections between structure (how the process is put together) and behavior (how it performs over time). They can compare their assumptions about the situation to the computer simulation and modify their mental models in response to what they learn.

Simple, controlled experiments can also create the activity basis for building shared understanding. A sequence of controlled experiments can yield extremely productive conversations, particularly when participants compare the results of the experiments to what they had predicted would happen. They can then discuss differences of opinion, identify commonalities of thought, and surface tacit assumptions.

Less directly, controlled experiments build an individual's capacity to accurately trace dynamics and to make structural/behavioral connections. Barry was a firm believer that humans aren't very good at doing mental simulations of anything except the simplest of systems. Nevertheless, he believed that people could build

their capacity to play out dynamics in their heads through sustained practice. Indeed, this was one of the motivations behind the "Story of the Month" concept.

Many of the stories reflected the principle of controlled experimentation, including the first one that HPS produced. This story came about because Barry was in California at the time of the run-up in energy prices that took place in April 2001. Everywhere he went, he read news articles about organizations that planned to pass on increased energy prices to consumers. This practice raised an interesting systems question: Is it possible for everyone to pass on costs? Or is there some self-limiting process at work?

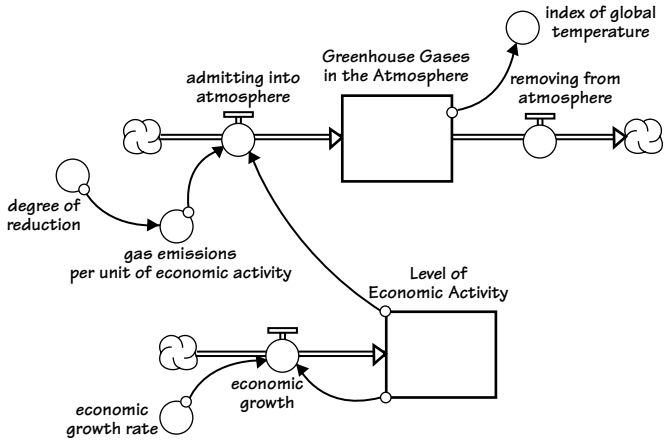
We developed a simple story to address the issue. The first part of the story looks at what producers do in response to a step-increase in energy costs. In the model, a simple balancing process is at work. In an experiment with a step-increase in energy costs, producer profits initially decrease. Producers then raise prices in order to bring profitability back to desired levels. When taken in isolation, this balancing process keeps profits at desired levels by passing on increased energy costs to consumers.

The next part of the story involves expanding the model boundary just a bit, to consider what consumers do in response. For consumers, an increase in prices means a decrease in purchasing power. This in turn can lead to upward pressure on wages. It's another balancing process. This loop works to keep purchasing power in line with desired levels by driving wages upward.

It's important to note, however, that wages are a cost to producers, and so an increase in wages can undermine producer profitability. In an experiment with the expanded model, a step-increase in energy costs leads to price increases, which causes wages to increase, which creates a further round of price increases! A reinforcing feedback process, latent within the structure of the system, underwrites a wage-price spiral! [Click here.]

By using controlled experiments in a simple progression, it's possible to build understanding, stimulate good conversations, and strengthen mental simulation muscles.

GROWTH, GASES, AND WARMING



This diagram facilitates investigation of the interaction between greenhouse emissions and the level of economic activity that serves as the base for generating those emissions.

4. The Principle of Mental Model Confrontation Like the principle of controlled experimentation, the principle of mental model confrontation is simple but powerful. The premise? Whenever possible, bring the prevailing mental model to the surface of the discussion. Explore the dynamic implications of that mental model. Then, provide an alternative mental model (often in the form of a stock and flow diagram) that offers richer explanations, more robust policy propositions, or improved insight into the issue at hand.

The process of confronting the default mental model is a key part of creating a compelling case for changed behavior—often the desired outcome of work in public policy. When there are multiple, conflicting mental models, the principle of mental model confrontation can be used to facilitate communication among key stakeholders. There's learning to be had from systematically comparing, testing, and evaluating underlying assumptions!

In late September 2001, Barry put together a "Story of the Month" on terrorism. This story nicely illustrates the principle of mental model confrontation. In it, Barry begins by "surfacing the mental model underlying [the rhetoric of the Bush administration in response to the September 11 attacks, for example, 'leading the world to victory in a war against terrorism'] so you can critically examine its implicit assumptions." [Click here.]

Next, Barry builds upon this simple mental model to offer a critique of the prevailing thinking. This richer structure—very similar to the one he developed for the 2001 Pegasus Conference—sheds light on longer-term difficulties for the "war on terrorism." Over the long haul, a reinforcing loop associated with the terrorist recruiting process, as turbocharged by increasing anger at US-led actions, can lead to a rapid growth in both the number of terrorists and the frequency of terrorist acts.

Later in this story, Barry offers a systems thinking–based alternative to looking at the situation. The alternative consists of two components: a defensive component that minimizes current threats, and an offensive component that gets to what Barry sees as the root cause of terrorism. Building it up a piece at a time, Barry ends up with a map that shifts from a focus on "winning the war" to building tolerance of another's viewpoint, managing anger, defusing hatred, and maybe even adjusting one's position. [Click here.] By initially confronting the mental model that appeared to be

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prevalent in the Bush administration, Barry presents a systems thinking–based alternative.

5. The Principle of Controversial Topics This principle flows directly out of Barry's deeply held view that anyone could (and should be able to) use the language, framework, and tools of system dynamics in a productive way. He believed strongly that an informed layperson could generate insight into any topic of interest. For Barry, controversial or "hot" topics were especially important to pursue, because they're often the most confusing or perplexing, and therefore have the most potential for benefiting from the use of system dynamics!

I've interspersed several of these controversial topics through this paper. To make the point very clearly, I'll introduce one more issue that Barry tackled in his "Story of the Month" series. In response to the tragedy at Columbine High School and at other schools in the United States, Barry put together the "Guns at School" story. He wrote, "Until we have a solid grip on the relationships responsible for producing and maintaining this scary phenomenon, we have scant hope of doing much to effectively address it." His story was an effort to come to grips with these relationships.

The story begins with a brief history of gun-related school violence and then incrementally develops a stock and flow map that seeks to explain the phenomenon. [Click here]. The map depicts the progressive build-up of alienation and rage, relating these emotions to the acquisition and use of guns within a student population.

Against this backdrop, Barry developed a set of policy-based experiments around three kinds of potential actions: gun-related initiatives (such as improved screening of gun purchasers, disarming students with guns, and restricting student access to guns), media initiatives (anti-copycat practices that limit news about school shootings), and student coping skills initiatives (trainings in rage, alienation, and humiliation management).

Barry's real legacy in public policy work resides in the mindset along with the principles that he employed.

Readers are prompted first to conduct one-at-a-time controlled experiments with different interventions. Then, in a second round, they are encouraged to create a "policy cocktail" to find the most effective set of interventions. The intent of these experiments is to provoke thought and stimulate discussion by exploring the relationships that drive this pressing social issue. Is the topic controversial? Yes! Is the story helpful in shedding light? Absolutely!

Barry's Legacy

Barry did not have a huge publication record in the realm of public policy. Most of his work was done in the context of client work or, more recently, in presentations of the "Story of the Month" column. I do not think that Barry's work, by itself, is where his legacy resides. Rather, as befitting the teacher that he was, Barry's real legacy in public policy work resides in the mindset along with the principles that he employed.

For those of us who wish to carry on the work, I believe that there is much to glean from this legacy. For me, the primary lessons are:

- Maybe not everyone can apply system dynamics to public policy issues, but there is a large population of people who could derive value, at some level, who currently are not. Those people need access to systems tools, concepts, and frameworks.
- Most people/organizations are on the steep part of the effort/value curve. They therefore can derive significant value from conversational uses of system dynamics, simple stock and flow maps, and simple models with interfaces.
- The five principles aren't rocket science—although there is some art associated with their application. I have found them helpful guideposts for my own work. You may find them useful as you seek to apply systems thinking in practical ways in your own context.

While it is beyond my ken to consider how one might replace someone like Barry, I believe that it is possible to carry on his work. It will require sustained effort and application, but it can be achievable. The world will be better for our efforts to do so. ◘

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RESOURCES BASED ON BARRY RICHMOND'S WORK

Available Through Pegasus Communications

www.pegasuscom.com

The "Thinking" in Systems Thinking: Seven Essential Skills, 26-page booklet

The "Thinking" in Systems Thinking: Honing Your Skills, 2-sided, quick-reference guide

Leveraging Successful Change Efforts: Moving System Dynamics from the Bedroom to the Dining Room and Kitchen, video program

Available Through isee systems

(formerly High Performance Systems)
www. iseesystems.com

STELLA® and *ithink*® system dynamics modeling software

The Connector, a free e-newsletter that includes a "Story of the Month"

Trainings and modeling support

Available Through Creative Learning Exchange

www.clexchange.org

Systems Thinking: Critical Thinking Skills for the 1990s and Beyond, paper

Systems Thinking in Education: Realizing a Fuller Potential, video program

Systems Thinking, Four Key Questions, paper

NEXT STEPS

In my view, system dynamics is very much a craft. Over time, with consistent practice, one can become effective at applying the thinking skills and frameworks in a variety of settings. But it's important to recognize that you don't have to be a builder of big system dynamics models in order to derive value from the application of the framework. If you are interested in building your conversational system dynamics skills, you might consider the following next steps:

- **Ask operational questions.** Instead of asking about the "factors that influence" a particular phenomenon, ask questions about "how it works." The questions are subtly different, but the responses you'll get are vastly more operational in nature.
- **Practice thinking in stocks and flows.** The stock and flow language is relatively easy to read but relatively hard to write. Your writing skills will improve through practice. Newspaper and magazine op-ed pieces are excellent springboards for developing your skills. After reading an article (or listening to a radio or television commentary), map out the key accumulations, flows, and connections in the author's argument. Then use the map to critique the argument.
- **Use the thinking skills in conversational ways on an ongoing basis.** *The "Thinking" in Systems Thinking* pocket guide and *The "Thinking" in Systems Thinking—7 Essential Skills* (published by Pegasus Communications) are two good resources to help you on your way.
- **Software tools can be helpful in creating maps.** They are essential for creating running simulations and sophisticated user interfaces for models. Among the more popular tools are:
  - *ithink*® and STELLA® software, produced by isee systems, inc. (www.iseesystems.com)
  - Powersim®, produced by Powersim Software AS (www.powersim.com)
  - Vensim®, produced by Ventana Systems, Inc. (www.vensim.com)
- **Formal training can provide a jump start in your skill development.** You may wish to contact software vendors for details on their training offerings or for references to consultants who create customized trainings.

WHY PUBLIC POLICY ISSUES?

From time to time in *The Systems Thinker*, we offer an article that focuses or touches on public policy issues. Last year, Adam Kahane's article "The Potential of Talking and the Challenge of Listening" (Volume 14 Number 10) used examples from South Africa and Guatemala to illustrate the need for new ways to communicate in order to solve highly complex problems. In "From Riots to Resolution: Engaging Conflict for Reconciliation" (Volume 13 Number 8), authors Jay Rothman and Chris Soderquist showed how groups in the city of Cleveland, Ohio, successfully applied participatory tools for engaging conflict to turn an intensely emotional debate about racial profiling into systemwide change. And in "A Systemic View of the Israeli-Palestinian Conflict" (Volume 13 Number 5), David Peter Stroh used the tools of systems thinking to offer a fresh perspective on a seemingly intractable and increasingly tragic situation.

Some readers may wonder why a newsletter that seeks to provide tools and ideas for creating better organizations includes material related to creating better societies. The answer is threefold. First, because they occur in large, complex systems, public policy issues often prove particularly daunting. By seeing how systems thinking and related disciplines can provide robust ways to tackle these challenges, we can more easily apply these concepts in our own contexts.

Second, societal issues offer examples that everyone can relate to, on one level or another. For instance, although we may not all be parents, the issue of school violence affects each of us, in terms of both our horror at the meaningless loss and the impact of changes in gun laws or tax hikes to pay for additional school security. Because our readers come from various roles within a wide spectrum of organizations, public policy issues—especially those highlighted in the popular news media—can offer a common frame of reference and powerful opportunity for learning.

Third, because we're all part of these larger systems, in many cases, we can be part of the solution. The decisions we make in our organizations can contribute to a shifting of the tide that can change our communities, countries, and world for the better. For example, considering Barry's model of the link between economic growth and the rise in greenhouse gases may cause us to make different choices about how we conduct business. And when we broaden our perspective to see the role we play in the larger system, we have a wider view of who our partners might be and how we might serve our own needs while supporting those of the whole.

So, we encourage you to pay close attention to examples that come from the societal realm, even if they may initially seem irrelevant to your immediate organizational concerns. We wager that, by doing so, you'll gain insights that will benefit you, your organization, and your world.

—Janice Molloy