# Crafting System Dynamics Models and Making Them Accessible: Lessons From Forty Years of Practice[1]

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**Abstract**
This paper shares reflections drawn from 40 years of experience crafting system dynamics models and commenting on policy-relevant modeling. It goal is to offer ten lessons about building and using models gained from that experience. Four modeling projects and a collaborative book describing the early years of global modeling provide context for the lessons presented. Here are three examples:

- Policy-relevant research that links system dynamics models with structures drawn from other modeling paradigms can be an effective communication device and may offer opportunities to broaden the reach of system dynamics modeling.
- Defining a problem based on a reference mode of problematic behavior may not be absolutely essential to developing a good model, but it is extraordinarily helpful. Reproducing a historical reference mode, ideally over an extended period of time, should not be the only confidence-building test for a model but it is an important one.
- System dynamics modeling should not primarily be viewed as a simulation technique that is distinguished by its increasingly elegant graphical user interfaces and interactive model-manipulation tools. The most significant value-added it provides is a powerful body of theory about the relationship between generic system structures and system behaviors.

## Introduction

**The challenge: encapsulating 40 years of model-crafting experience into a forty-five minute lecture.**

This paper's genesis is an opportunity I was given, about two years ago, to give a one-hour lecture to graduate students in Singapore's Lee Kuan Yew School of Public Policy who were in the early stages of their first system dynamics modeling class. My goal was to introduce them to

[1] This paper has been accepted as a Plenary Session presentation at The 29th International System Dynamics Conference in Washington, D.C. Since the draft is preliminary, please do not reproduce or share without permission. Comments sent to jrich@american.edu would be welcomed.

the field, to convince them of its value and to empower serious engagement. I had taught similar classes at both American University and, before that, at Case Western Reserve University for many years. Opportunities for such brief introductions, though the audience may be public officials, rather than students, come with some frequency and always pose a challenge. What value added can one most meaningfully provide in a 45 to 60 minute time frame? If one engages in story-telling, an especially tempting option for those of advanced years, the audience may be engaged, but leave the room with little practical guidance for their own work. If one focuses on a specific project the audience may miss learning from the breadth of experience than an "outside speaker" can provide. If one focuses on more technical issues, the audience may be impressed with one's erudition, but lack proficiency to put what is being presented to good use.

I assumed that most students choosing to study system dynamics modeling at the Lee Kuan Yew School would be concerned, like Professor Jay Forrester, himself, with understanding systems in order to improve the quality of business management or public policy decision making. This was a common thread that had run through more than 40 years of my modeling-oriented work, though the subject matter was diverse: urban development and governance, water quality management, sustainable global development, violent-conflict–development linkages and now, Singapore as a sustainable development model. Reflecting on the experiences this work had provided, I sought to identify a manageable number of practical lessons about building models and having model results make a difference that my audience of nascent modelers could list on a single page, (or manageable iPhone or iPad sized file), and carry away with them for future use. Many were lessons I had shared with my own students or with colleagues, over the years. The result was a lecture that shares a title with this paper and upon which this paper builds.

Choosing the term "crafting" with which the title begins, is not casual. It owes inspiration to Herbert Simon's brilliant essay "The Sciences of the Artificial" (1969, pp. 5,ff). Simon characterizes the work of engineers as creating artifacts that embody both elements of science and human purposes that are intended to "attain goals and to function." A second inspirational source was my first wife, Jan Richardson whose discipline and creativity as a ceramic artist it was my privilege to observe from the vantage point of the home we shared as I was writing many of the earlier papers cited in this one. In one of the books discussed in this paper, *Groping in the Dark: The First Decade of Global Modeling* (1982)*,* my coauthors and I wrote, "Global modeling is not a science. It is more like a craft. What global modelers do is more like pottery, architecture, cabinetmaking and bonsai than like astronomy, physics, chemistry, biology or mathematics." I believe that system dynamics modeling, too, is more usefully viewed as a "craft" than a "science."[2]

## Ten lessons from five projects

Rather than simply generalizing, I have chosen to link lessons learned to brief descriptions of five diverse projects (all but one collaborative). Four produced one or more models targeting a specific problem. One surveyed a number of contributions to the field of "global modeling." The five projects, discussed in chronological order below, are these.

1. A model that built bridges between system dynamics modeling and multilevel hierarchical systems theory (Mesarovic, et. al., 1970) by linking a political "controller" to Jay Forrester's

[2] I have left this quote as we wrote it in 1981 rather than adding some contemporary examples from, for example, computer-assisted graphic design or video animation that might have made it more palatable.

*Urban Dynamics* model. Papers then explored theoretical and policy-relevant implications of the linkage (Richardson and Pelsoci, 1972a, b).

2. A policy-oriented model of the eutrophication problem in the Lake Erie ecosystem (Richardson and Klabbers, 1974; Rolan, 1976).
3. The food and agriculture sector of the hierarchical multilevel regionalized world model. (Mesarovic and Pestel, 1974; Mesarovic and Richardson, 1973).
4. *Groping in the Dark: The First Decade of Global Modeling* (D.H. Meadows, Richardson and Bruckmann, 1982), which surveyed a number of global models. It sought to draw lessons for modeling practice and public policies related to global sustainability issues from the models and experiences of the modelers who had crafted them.
5. A series of models, seeking to explain conflict-development linkages and offer recommendations for preventing deadly conflict (Richardson, 1987a, 1987b and 2005 along with many others).

One lesson my co-authors and I learned from writing *Groping in the Dark,* was the value of highlighting what we believed to be most important and placing it early in the book where reviewers and readers would be sure not to miss it, even of they read no further. I have followed this practice in every book and paper I have written ever since. Hence, for readers whose time is limited or, for whatever reason, choose not to read beyond these few pages, here are the ten lessons that will be contextualized and discussed, below.

**LESSON 1**: ***Policy-relevant research that links system dynamic models with differing structures from other modeling paradigms can be an effective communication device and may offer opportunities to broaden the reach of system dynamics modeling.***

**LESSON 2**. ***Defining a problem based on a reference mode of problematic behavior, unfolding over time, may not be absolutely essential to developing a good model, but it is extraordinarily helpful. Reproducing a historical reference mode, ideally over an extended period of time, should not be the only confidence-building test for a model but it is an important one. Also, it often increases client confidence in a model even when, perhaps, it shouldn't.***

**LESSON 3:** ***If a model generates "surprising" behavior that turns out to be true, one can justify placing more confidence in other scenarios it generates.***

**LESSON 4**. ***Incorporating detail in a model, even if it is not consequential for the model dynamics may be helpful in winning support from discipline-based scholars and impressing potential clients. This can be done in a manner that does not compromise the model's dynamic behavior or the modeler's integrity.***

**LESSON 5.** ***Organizing a conference/symposium that is intended to produce a significant contribution of lasting value is not something to be undertaken lightly. To ensure success requires a clearly defined subject, a clear vision, financial and logistical resources, a supportive venue, a committed organizing team that knows the subject, the participants and each other and a group of participants with a similar knowledge and commitment to the final outcome.***

**LESSON 6.** ***Modelers studying similar problems whose work is framed by different paradigms may devote too much time to arguing about relatively arcane methodological***

***differences and fail to emphasize points of consensus on more fundamentally important matters.***

**LESSON 7.** ***When considering how to make work you believe is important accessible, it is worth taking risks and affronting conventional wisdom. Sometimes, the results may pleasantly surprise you***.

**LESSON 8.** ***System dynamics modeling should not primarily be viewed as a simulation technique that is distinguished by its increasingly elegant graphical user interfaces and interactive model manipulation techniques such as sliders and gaming packages. The most significant value-added it provides is a powerful body of theory about the relationship between generic system structures and system behaviors.***

**LESSON 9**. ***The parable about a group of blind monks quarreling over their description of an elephant aptly describes the quarrels among social scientists about which explanation of conflict development linkages (and many other phenomena of interest) is "correct." A good system dynamics model can reveal connections between the elephant's extremities, but this does not mean that blind monks will resolve their quarreling.***

**LESSON 10.** ***A good system dynamics model may cast significant light on a problem's causes and even point to possible solutions. But, even when the modeler is respected and viewed as credible by senior government officials that does not mean his recommendations will be implemented or, if they should be, that the outcomes envisioned will ensue.***

## Hierarchical, Multilevel Systems Theory

### A political "controller" for the *Urban Dynamics* model based on Mesarovic's theory of hierarchical multilevel systems.

"Be open to the opportunities serendipity may offer" might be among the most important lessons to which I would point, though I have not highlighted it. Here is the story of how I first encountered system dynamics modeling. I have shared this with doctoral students on many occasions.

In the fall of 1970, I had completed a year of postdoctoral work in mathematics and began teaching political science, as an Assistant Professor at Case Western Reserve University. I knew nothing of system dynamics modeling or Jay Forrester. My work had focused on mathematically explicating Herbert Simon's concept of "satisficing," (1957) using Mihalo Mesarovic's algebraic representations of multilevel hierarchical control theory (et. al, 1970). One afternoon, a young Hungarian refugee, Thomas Pelsoci, appeared at the door of my small office. He said he had an engineering background but wanted to write a Ph.D. dissertation with me – and he needed financial support.

I strongly advised against this course of action, pointing out that a junior assistant professor, with no access to financial resources, was not a good prospective Ph.D. supervisor. Pelsoci persisted. He stubbornly refused to take "no" for an answer. Finally I decided to see what could be done. Professor Mihalo Mesarovic, whose work I had been studying, was an internationally recognized mathematical systems theorist and Director of Case Western Reserve's Systems Research Center in the School of Engineering. The possibility that I might work with him had been a prime motivator drawing me to Cleveland. In the previous year, using funds from an NSF grant[3], my mentor, Robert Holt, and I had persuaded him to spend a few days with us at our University of Minnesota Research Center, speaking about his work and discussing possible collaborative research. I called Professor Mesarovic and asked if he would provide funds for Pelsoci's political science graduate study under my supervision.

In response to my request, Professor Mesarovic offered a proposition. He said that there was interest among funders in applying systems engineering theories to social problems, especially urban problems. He shared that critics had been asking why we could not solve the problems of urban decay in our cities if we could accomplish such feats as putting a man on the moon. Mesarovic said that he would fund Pelsoci's doctoral study and provide me with additional funds as well, if we would agree to develop an application of multilevel hierarchical systems theory to some social problem and publish it in a major refereed journal.

While task seemed a bit daunting, I was by now committed to helping Pelsoci and agreed, without hesitation. I was immediately provided with an office in the School of Engineering plus support and additional space for Pelsoci as well as funding for his graduate study. Additional computer and staff support (computer support was an expensive perk on those days) was also forthcoming. Soon afterwards, Mesarovic called my attention to an upcoming conference being organized in less than a year's time to "react" to Jay W. Forrester's recently published book, *Urban Dynamics* (1969). *Urban Dynamics'* controversial diagnoses of urban blight and proposed remedies had raised the book's profile to a high level in both public policy and academic circles (Alfeld, 1995). He suggested this would be a good venue for presenting the results of our work.

We had no contact with Forrester's group at MIT and no access to the DYNAMO compiler. As a very junior assistant professor of political science, it did not occur to me that a visit to MIT was in order – which may have been fortuitous. We simply ordered a copy of *Urban Dynamics,* which thankfully included the complete documentation that Jay Forrester demanded (and demands) of himself and his students. Pelsoci rewrote the entire model in FORTRAN, while I figured out how to translate my algebraic control theoretic representation of political decision making into code that would link to our FORTRAN version of the *Urban Dynamics* model.

Mesarovic's multilevel philosophy proved extraordinarily helpful in this endeavor. Had we been trained in system dynamics modeling at MIT we would, no doubt, have chosen to build the model in DYNAMO, to represent decision processes using system dynamics; and to avoid complex algebraic representations based on multi-level hierarchical systems theory. Many readers may not have fully understood our work, however it combined systems engineering and political science jargon. It cited "relevant literature." Our work was much less visible that *Urban Dynamics*, of course, but seemed appealing to systems engineers as an example of how theories with which they were familiar might be applied to social problems.

Because of the lower profile of our work and its mathematical complexity, we were also able to skirt the controversies with which many proponents of the urban dynamics model became embroiled (Alfeld, 1995). Interestingly, my recent studies of Singapore have revealed policies that not only resemble recommendations that Jay Forrester mooted in *Urban Dynam*ics but the control-theory based principles of governance Pelsoci and I had described (Richardson and Ong, 2010). I cannot say-that our eclectic approach produced a better model than what we would have

[3] The grant was to explore "Applications of Mathematical Automata Theory to the Study of Political Development" (Holt and Richardson, 1970)

come up with had we represented political and administrative decision processes using system dynamics, but I do believe it points to the following lesson:

**LESSON 1**: ***Policy-relevant research that links system dynamic models with differing structures from other modeling paradigms can be an effective communication device and may offer opportunities to broaden the reach of system dynamics modeling.***

**A policy-oriented model of Lake Erie's eutrophication problem**

By 1971, I was spending most of my time in the Systems Research Center, and had begin work on a project to model the role of detergent phosphorous in the eutrophication (over-fertilization) of Lake Erie. A substantial Rockefeller Foundation grant was providing funding. Soon after the project began, a Dutch Scientist and system dynamics modeler, Dr. Jan Klabbers arrived to begin a yearlong residence at the Center. He was to become an invaluable collaborator in the project.

However it was a second project just recently initiated, that was to provide a unique exposure to system dynamics modeling and fundamentally alter my views about how models should be crafted. In 1971, the MIT System Dynamics Group, following presentations of Jay Forrester's World1 and World2 models, had received funds from the Volkswagen Foundation, under auspices of the Club of Rome, to build a "global model." The model was intended to address broad-ranging long-term issues senior Club members had variously described as "The Global Problematique" or "The Predicament of Mankind" (Peccei, 1977; Executive Committee of the Club of Rome, 1972). [4] I remember first thinking this was fanciful and responding to Professor Mesarovic's description of the project with a one-liner: "If Professor Forrester's group can model the world, then we should be able to build a multilevel hierarchical control system to manage it?" The story of how Dennis Meadows was named to lead a group tasked with adding "real data" to Forrester's preliminary *World2* model (1971) and how the resultant events-chain led to publication of *The Limits to Growth* (Donella Meadows et. al., 1972) and, later, *Dynamics of Growth in a Finite World* (Dennis Meadows, et. al., 1974) has, of course, often been described (e.g., D.H. Meadows, et. al., 1983; D.H. Meadows, 2007).

By spring 1972, there had been preliminary discussions about tasking a group, to be led by Mesarovic and Club of Rome Executive Committee member, Eduard Pestel, that would produce a second global model. The model was to be disaggregated into regions and represent specific policy options that could not be addressed in the highly aggregated World3 model on which *The Limits to Growth* was based. In part, the project was intended to respond to criticisms of World2 and World3, particularly from economists.

As part of the MIT Group's outreach program, Dennis Meadows and his project colleagues had agreed to introduce the World3 model to a select group of predominantly European scholars and policy makers at a NATO Advanced Study Institute. Meadows asked Mesarovic if he would send a member of the Case Western Reserve group to participate and speak about the new project. Mesarovic chose me for the assignment. My colleague Barry Hughes, who was already engaged in the global modeling work, was a more logical choice for this perk, but this would be the first time I had the opportunity to travel to Europe. My wife was able to join me and I was not about to turn down the assignment.

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[4] The Club of Rome was an influential group of businessmen, scholars and leaders of international organizations, predominantly European, founded by Italian Businessman and visionary, Aurelio Peccei. Mesarovic's friend and soon-to-be collaborator, Eduard Pestel, was a Club of Rome Executive Committee Member.

Meadows' and his colleagues[5] accepted me graciously as a member of their close-knit community, including me not only in teaching sessions, which introduced participants both to World3 and system dynamics modeling, but also in their staff planning sessions and socializing. This provided a unique window on the circumstances that had 'birthed' *The Limits to Growth* and on the opportunities and challenges its subsequent high profile created. My previous knowledge of system dynamics was entirely self-taught; the teaching sessions and workshops provided my first formal introduction.

When the NATO Institute ended, I returned to Cleveland and my collaborative work on eutrophication, but with a new appreciation of sustainable global development issues and system dynamics, as well as connections that were to become lifelong friendships. Most important, my modeling paradigm was transformed. Though I never labeled myself as such, and did not actually use the DYNAMO software until several years later, I became an outpost of system dynamics modeling practice within the inner circle of Mesarovic's group. A first consequence was that the Lake Erie model took a very different form than otherwise would have been the case.

The model[6] (See Figure 1) exemplified two key system dynamics principles: *the importance of modeling problems, not systems* and the *importance of representing problems as graphs of measureable (or at least measurable in principle) behavior over time*. "The problem that had motivated creation of the model was high levels of oxygen depletion in the lower reaches of Lake Erie's central basin (hypolymnion) during summer months. This had led to articles describing the lake as "dead" in public media, with suggestions that this might presage problems in the other Great Lakes. Possibly**,** those articles may have helped motivate Rockefeller Foundation Board members to fund our modeling work.

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[5] Those participating in the NATO Institute included Dennis and Dana Meadows, Jurgen Randers, Bill Behrens, Peter Milling, Erich Zahn, John Seeger and Jack Pugh.

[6] Model documentation and descriptions of model results are found in Richardson and Klabbers (1974) and Rolan (1976). Interestingly the model-based analysis described in the latter three-volume report was conducted with virtually no input for the model's authors. By the time Rolan contacted the Systems Research Center, on behalf of the consulting firm Dalton, Dalton and Little, I was deeply involved in global modeling work, including a very demanding international travel schedule. Dr. Jan Klabbers, my co-author, had returned to his home university in the Netherlands.

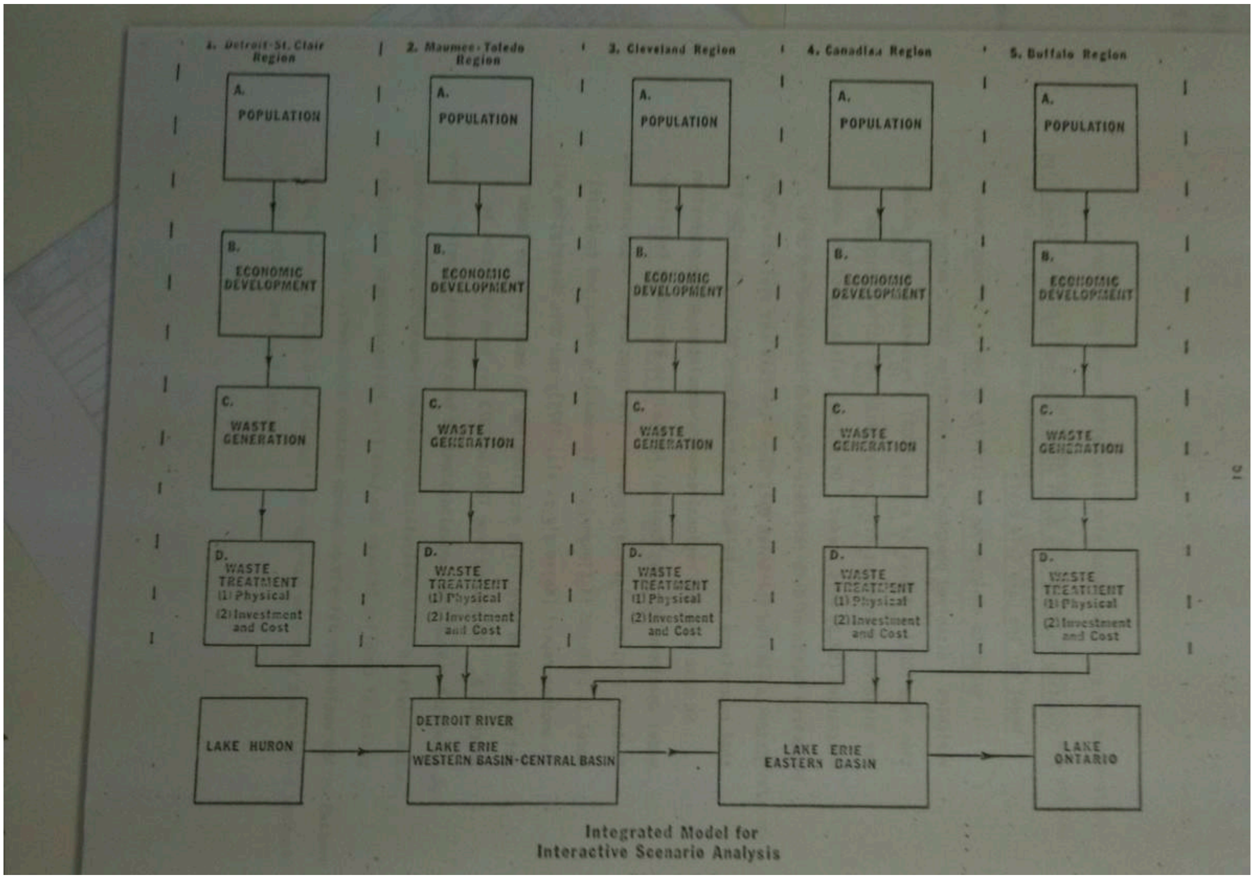


Figure 1. Multilevel Model of the Lake Erie Basin and Watershed

Initially, our reference mode was the mean depletion rates for dissolved oxygen in the central basin bottom waters (see Figure 2). But we (Klabbers and myself) soon realized that this was a concept that many planners and policy makers who were interested in our project results had difficulty grasping. Developing a parallel reference mode, called "days of anoxia" enabled us to communicate model results in a manner that policy makers and other non-technical audiences could more fully understand.

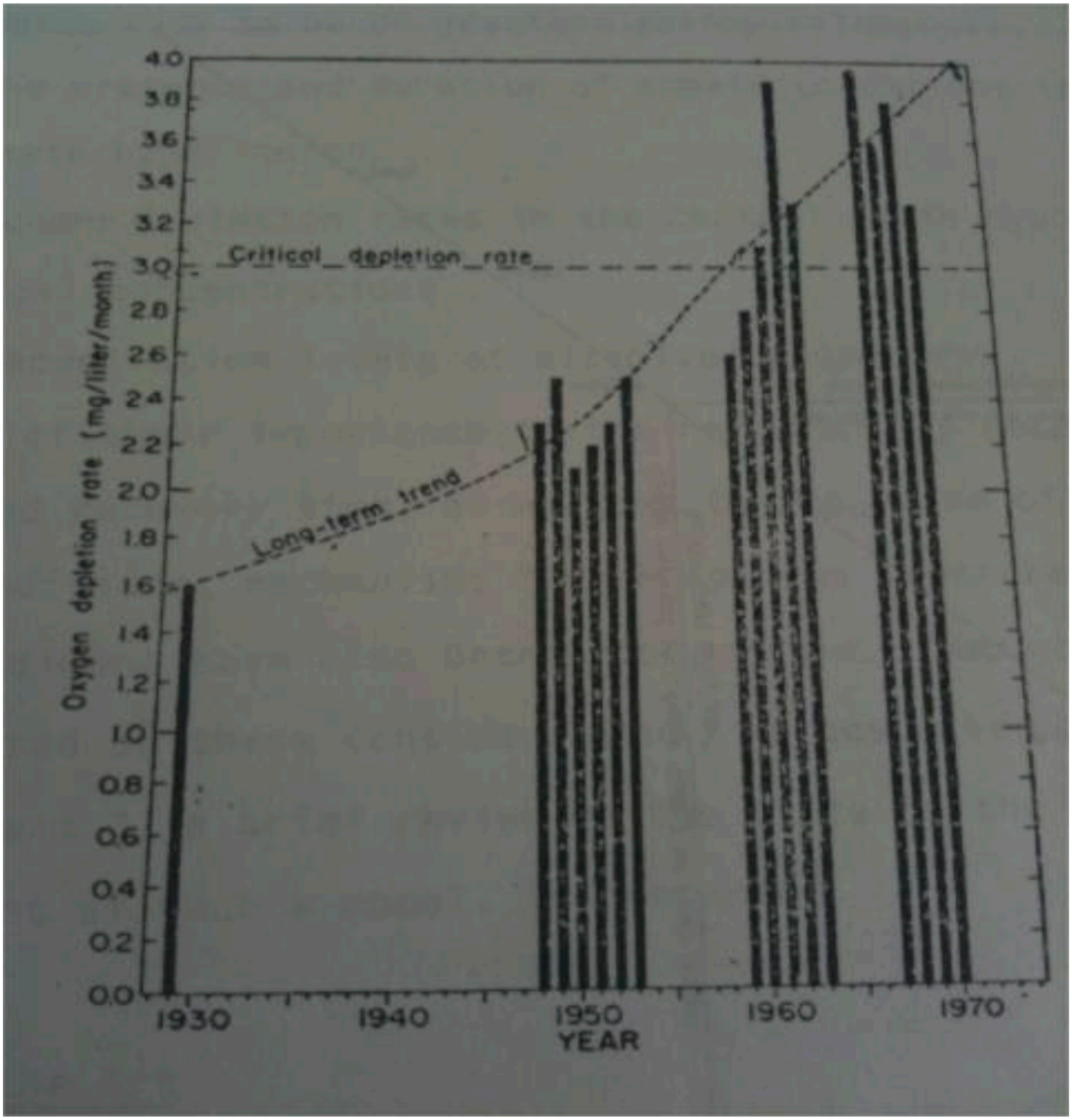


Figure 2. Reference Mode: Oxygen Depletion in the Lake Erie Central Basin Hypolymnion

But how were we to model the wastes flowing the lake that the complex demographic-economic-industrial-political system of the Lake Erie Drainage basin generated? Here Mesarovic's multilevel approach again proved helpful. Working with a collaborator in Case Western Reserve's Chemical Engineering Department, Dr. Richard Prober, we developed regression-based models that would generate the appropriate levels of waste, though there would be no feedback from the lake**,** itself. For the 1950-1975 period, with one significant exception to be discussed below, the results were consistent with historical eutrophication patterns. This pointed to the following lesson:

**LESSON 2**. ***Defining a problem based on a reference mode of problematic behavior, unfolding over time, may not be absolutely essential to developing a good model, but it is extraordinarily helpful. Reproducing a historical reference mode, ideally over an extended period of time, should not be the only confidence-building test for a model but it is an important one. Also, it often increases client confidence in a model even when, perhaps, it shouldn't.***

Moreover, absent our commitment to reproducing problematic behavior, we would almost certainly have failed to note a result that increased our confidence in the model and the confidence of potential clients to whom we presented it.[7] John Sterman uses the label "surprise behavior" (generation of "previously unobserved or unobserved or unrecognized behavior") to describe this (2000, p. 860). [8].

As noted above, one of our goals was to reproduce mean oxygen depletion rates in the Central Basin hypolymnion. Between 1950 and about 1972**,** the model produced results that were stable, but somewhat higher than the reported data. It was producing more phosphorus was actually impacting the lake's ecosystem, in other words. To correct the problem it was necessary to introduce a coefficient that arbitrarily reduced phosphorus discharges so that depletion rates and days of anoxia matched the reported data. Beginning in 1972 and continuing through 1974, however, the model-generated-results drifted toward the reported data, and by 1975 tracked it closely. Thus, from 1972 through 1975 it was necessary to gradually reduce the coefficient's value to zero, producing an increase in phosphorus loadings to an unadjusted level.

This arbitrary adjustment in phosphorus input levels forced the desired model behavior, but what was the explanation? Further research provided an answer. Our modeling had failed to take into account a "mixing zone" phenomenon at the northwestern mouth of Lake Erie, where substantial discharges from the Detroit River and smaller rivers draining lakeside industrial areas originated. But it also helped us to "discover" this phenomenon and include it in our analysis.

Beginning in about 1970, there was rising public concern about pollutant discharges, especially from Detroit and its environs. Beginning in 1972**,** a series of Lake Erie Enforcement Conferences were held. A result of these conferences**,** along with public pressure, was a significant reduction of effluent discharges from steel mills adjoining the Detroit River and its tributaries. Obviously, no one wanted hydrochloric acid polluting drinking water sources and recreational swimming areas. However**,** the acid discharges did have one beneficial effect. They caused the precipitation of substantial amounts of phosphorus from effluent and "distributed-source" discharges, rendering the phosphorus inert. This meant that phosphorous discharges were significantly lower than the levels that our statistical model predicted. Our fudge factor (which my colleague Jan Klabbers renamed "the sludge factor") had taken this "mixing zone" phenomenon into account. Our experience pointed to Lesson 3, which, as already noted, has also been highlighted in some textbooks on modeling and professional papers.

**LESSON 3:** ***If a model generates "surprising" behavior that turns out to be true, one can justify placing more confidence in other scenarios it generates.***

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[7] As the model was being developed and results presented, we dialogued frequently with local water pollution control agencies and with the Cleveland office of the Army Corps of Engineers. Rolan (1976) describes how the model was later used as a basis for recommendations by the U.S. National Commission on Water Quality

[8] Another "surprise behavior" example widely known in system dynamics modeling circles is the "discovery" of the economic long wave or Kondratiev cycle Forrester (1977; 1983), Sterman (1986). I first heard this described by Professor Forrester in a personal conversation.

**The Food and Agriculture Sector of the Multi-level Multi-Regional (Mesarovic-Pestel) Global Model**

Water resources modeling at the Systems Research Center suffered the same fate as urban dynamics modeling at MIT's System Dynamics Group. It receded in importance as attention and resources were redirected to "global modeling" work that was more in the public eye. The high profile of this new research area was due largely to *The Limits to Growth's* success in communicating a powerful message that highlighted the potential challenges of global-scale overshot and collapse. For nearly a decade, beginning with modeling work that supported the "Second Report to the Club of Rome," *Mankind at the Turning Point,* and continued through the publication of *Groping in the Dark: The First Decade of Global Modeling* (D.H. Meadows, et. al. 1983,) and the 10th IIASA Global Modeling Conference, Global Modeling became the major focus of my work (e.g. 1978a,b; 1982; 1988). Thus, it is surprising to recall that I only joined the Mesarovic-Pestel global modeling group about five months before the group's first public presentations at the Woodrow Wilson International Center for Scholars, again under serendipitous circumstances.

Here is how events transpired. The group member responsible for food and agriculture was a gifted, knowledgeable ecologist who had been chosen for his extensive knowledge of food production and nutrition. Over a period of about a year, he had created and become passionately committed to a very detailed food-sector submodel, comprising 37 food types. But as the date for major presentations loomed closer, two problems were becoming matters of growing concern. First, the model was unable to link to other model sectors, and second, its output did not bear much resemblance to historical data. In particular, it generated bountiful harvests in the South Asia region, which was to be a major focus of model scenarios, where the problems of food shortages and starvation were evident to all. This led to lengthy discussions at group meetings in which Professor Mesarovic called attention to these shortcomings and the ecologist resolutely defended the elegance, sophistication and theoretical validity of his 37-food type representation.

To resolve the problem, while maintaining group cohesion, Mesarovic assigned me a low profile project, to be carried out in parallel, that would link with other model sectors and reproduce historical data, while the work on the more complex sub-model continued. This simpler model, which became the basis for the food and agriculture sectors described in *Mankind at the Turning Point,* embodied system dynamics principles though, like the Lake Erie model, it did not use DYNAMO. The breakthrough that made a viable model, producing historically reasonable results possible, was translating all of the 37 food types into common unit, edible protein. The only disaggregation was between consumable and animal protein. The latter required range forage and produced forage (grain, hay etc.) to be taken into account, of course.

But what to do with the 37 food type submodel, which produced a level of detail that appealed to potential clients and for which the project had accumulated masses of data? Our colleague's tenacious commitment to the model also had to be taken into account. The solution was to incorporate fixed coefficients for each food type, derived from the edible protein data, independent of model dynamics. This allowed the model, for particular scenarios or snapshots, to generate data for manioc in Africa, pulses in South America rice in South Asia corn and beef in North America and much more. These data produced some richly textured illustrative results that were eloquently highlighted in presentations by our ecologist colleague. Collegiality and cohesion in our group, during the intense weeks leading up to our presentations at the Woodrow Wilson Center and IIASA, was sustained. This experience points to Lesson 4.

**LESSON 4**. ***Incorporating detail in a model, even if it is not consequential for the model dynamics may be helpful in winning support from discipline-based scholars and impressing potential clients. This can be done in a manner that does not compromise the model's dynamic behavior or the modeler's integrity.***

### *Groping in the Dark: The First Decade of Global Modeling*

### The 'field' of global modeling: IIASA's role

Nearly forty years after *The Limits to Growth*'s publication, computer models have been commonplace and issues of "sustainability" are widely accepted in public discourse (though, the *Limits to Growth*'s message remains controversial). It may be difficult to recall the degree to which the report describing this highest profile global model and its scenarios of possible global-scale overshoot and collapse became a matter of global public debate; unless one was a protagonist in the debate, that is.

Among the debate's products was the relatively short-lived "field" of "global modeling," the early years of which are chronicled in *Groping in the Dark: The First Decade of Global Modeling.* This early history of global modeling is inextricably linked to the history of the International Institute for Applied Systems Analysis (IIASA), founded in 1973, soon after *The Limits to Growth* was published. IIASA's home was a picturesque former Austrian imperial mansion (*Schloss)* located in the village of Laxenberg, outside of Vienna. It's mission was to promote dialogue between Western and Soviet bloc scientists by conducting scientific research on non political topics of common interest (for example systems and control theory, environmental quality, energy resources, and the like). [9]

Global modeling seemed to some like a logical candidate for a IIASA project, but the Institute's Executive Committee decided the field was too controversial. Instead the Committee and IIASA's founding Director, Howard Raffia chose a "clearing house" role that would provide a forum for major global modeling projects and focus on methodological issues. Gerhart Bruckmann, then Professor of Statistics at the University of Vienna and Director of the Vienna Institute for Advanced studies was appointed to oversee the effort.

Organizing "Global Modeling Symposia" and publishing of symposia proceedings became IIASA's principal global-modeling-related activity. When a group anticipated that results of their work would be forthcoming, they would establish contact with Professor Bruckmann who would schedule a symposium. Beginning in 1976, more than one major presentation at each symposium was typically scheduled. On the last day or so of each event, participants not giving major presentations would describe ongoing work and plans for future symposia would be discussed. The conferences offered an unique venue for contributors to this nascent field to gather, become acquainted and share ideas in a bucolic neutral setting, facilitated by Professor Bruckmann's superb diplomatic skills. Since some global models had been developed explicitly to question the methodologies and results of others, and public debates could be fractious, the IIASA symposias' ambience of civil collegiality was much appreciated.

[9] Much of this early history is recounted in an evaluation of the Institute's international role that I wrote for the National Science Foundation's Division of International Programs (1978c). For a more recent discussion see MacDonald (1998).

### A retrospective symposium on the field's early years

*Groping in the Dark: The First Decade of Global modeling*, which became a retrospective on the field's early years reflected this. Its genesis was the Sixth IIASA Global modeling symposium, which, in contrast to its predecessors, was intended to fulfill IIASA's mandate of providing methodological appraisals of the still nascent field. Representatives from six projects agreed to participate (1983, Chapter 3). In contrast to many conferences, the agenda was highly structured and required participating groups to prepare extensively. Gerhart Bruckmann, Donella Meadows and I, who constituted ourselves as the symposium's planning committee, prepared a detailed questionnaire to which group members were asked to respond in writing, and on which they were asked to base their contributions. Respondents were asked to target seven issues:

1. The purposes and goals of global modeling
2. Methodology
3. Actors, policy variables
4. Structural aspects (the model variables, level of disaggregation, mathematical relationships)
5. Testing the model (procedures to build confidence in the model and its results, for team members and others)
6. Internal organization (of the group that created and used the model)
7. Relations between the modeler and user.

The issues addressed were among the most important that differentiated the six models and had often been topics of debate – sometimes highly public. Instead of organizing conference sessions around the individual models, the questionnaire topics became the basis for presentations by group representatives. Each session was chaired by a rapporteur/evaluator who not only facilitated discussions, but also produced a synoptic commentary. Rapporteurs included the three organizers and other modeling professionals. Synoptic commentaries were returned to participants for additional review and feedback, in some cases extensive. As I reflect on this process it points to an important lesson, not specifically related to system dynamics that seems obvious, but all-too-rarely acknowledged. Because it seems so rarely to guide the organization of symposia and conferences, I have included it.

**LESSON 5.** ***Organizing a conference/symposium that is intended to produce a significant contribution of lasting value is not something to be undertaken lightly. To ensure success requires a clearly defined subject, a clear vision, financial and logistical resources, a supportive venue, a committed organizing team that knows the subject, the participants and each other and a group of participants with a similar knowledge of the subject and commitment to the final outcome.***

### A different kind of conference proceeding

When Professors Meadows, Bruckmann and I convened at IIASA, a year after the symposium's conclusion the products of the conference discussions and the results of substantial editing awaited us. We had a general idea that the proceedings should, like *The Limits to Growth* and other "Reports to the Club of Rome," appeal to a wider audience than modeling professionals and the customary audience for IIASA publications. Meadows and I had already begun collaborative work on two other books, with no relationship to modeling, that were intended to create public awareness about two issues that our respective global modeling work had crystallized – ending hunger (The Hunger Project, 1985) and the importance of envisioning a positive future (Ed., 1982). This had begun sensitizing us to the challenges making complex technical materials accessible and engaging.

Thus, as our collaboration unfolded, we made the collective decision to embed our report on the symposium discussions in a book that would appeal to a much wider audience by telling the story of this path-breaking and controversial field from a vantage point that included our own reflections. Further, we chose to state our own values unambiguously and to describe candidly how they had shaped – and not shaped – what we had written. We sought to create a book that would appeal not to one audience, but three (p. ix).

> "AUDIENCE #1. Those who make computer models of complex social systems (the symposium participants and their colleagues).
>
> "AUDIENCE #2. Those who are formally responsible for making complex social systems work (the decision-makers and policy formulators we hear so much about).
>
> "AUDIENCE #3. Those who live in and care about the complex systems that the modelers model and the decision-makers decide about."

"In the case of global models," we emphasized, Audience # 3 consists of everyone."

To differentiate our book from typical academic tomes and conference proceedings, we proposed a format in which different themes were printed on pages of different colors. This was inspired by Stafford Beer's similarly unconventional volume, *Platform for Change.* YELLOW PAGES were for "the personal thoughts, and reflections that every author has but that are mostly filtered out in the editorial process." (In fact, now these appear much more commonly in social media.) BLUE PAGES were for the most important conclusions and highlights from the conference. WHITE PAGES comprised the conference proceedings, including modeling group questionnaire responses and evaluators edited commentaries. GOLDENROD PAGES introduced the field of global modeling and its history.

One rationale for this scheme was a supposition that reviewers and many readers of the 300 page book might limit themselves to the colored pages and that some might limit their attention to the blue pages and perhaps a few of the yellows that they encountered *en passant*. (Anecdotal information from those with whom we later discussed the book suggests that is exactly what happened in many instances.)

**Areas of agreement: common lessons from diverse global models**

Before completing the story of *Groping in the Dark*'s publication a powerful lesson we earned long before the book was completed merits highlighting. As we went through the symposium materials and began writing, the realization that we had missed in important insight kept nagging at me. One morning, I was sitting alone in our IIASA workroom, with the materials we had assembled piled everywhere, and it came to me. The global modeling field's principal image was of a contentious group of scholars who spent most of their time disagreeing with one another and seeking to discredit each other's work. Most of the symposium topics we had chosen were intended to explore those disagreements. In fact we had not even included areas of consensus on our list. ***Yet when one viewed the corpus of work as a whole, it became clear that on most points of fundamental importance to "audience 2" (policy makers) and especially to "audience 3" (all of us) there was fundamental agreement).*** When I shared this realization with my two colleagues, they agreed that this might in fact be true and we eagerly set about compiling common messages on which all the global modelers could agree. Though I cannot offer other than anecdotal evidence, I know that the twelve "common, general messages" that emerged from our discussions were repeated in book reviews, policy papers, congressional briefings and many other venues. They remain *Groping in the Dark*'s most important contribution. Among them, here are seven that seem most relevant to an audience particularly concerned with system dynamics modeling (1982, pp. 16-17).

[1] *There is no known physical or technical reason why basic needs for all the world's people cannot be me into the foreseeable future. These needs are not being met now because of social and political structures, values, norms and worldviews, not because of absolute physical scarcities.*

[2] *Population and physical (material) capital cannot grow forever on a finite planet.*

[7] *Owing to the momentum inherent in the world's physical and social processes, policy changes made soon are likely to have more impact with less effort than the same set of changes made later. By the time a problem is obvious to everyone, it is often too far advanced to be solved.*

[9] *The interdependencies among peoples over time and space are greater than commonly imagined.*

[10] *Because of these interdependencies, single, simple measures intended to reach narrowly defined goals are likely to be counterproductive. Decisions should be made within the broadest possible context, across space, time and areas of knowledge.*

[11] Cooperative *approaches to achieving individual or national goals often turn out to be more beneficial in the long run to all concerned than competitive approaches.*

[12] *Many plans, programs and agreements, particularly complex international ones, are based upon assumptions about the world that are either mutually inconsistent or inconsistent with physical reality. Much time and effort is spent designing and debating policies that are, in fact simply impossible.*

We provided our bottom-line conclusion in capital letters:

> In short: CHANGE IN THE STATUS QUO IS CERTAIN. IMPROVEMENT IN THE STATE OF THE WORLD IS BY NO MEANS IMPOSSIBLE AND BY NO MEANS GUARANTEED. WE ARE A LONG WAY FROM KNOWING EVERYTHING WE NEED TO KNOW, AND YET WE KNOW ENOUGH ABOUT WHERE WE WANT TO GO AND HOW TO GET THERE TO GET STARTED. THE SITUATION IS NOT HOPELESS. IT IS CHALLENGING.

**Winning approval for a risky project**

It only remains to complete the story of *Groping in the Dark* – so far. The genial and immensely supportive Director of IIASA publications, Hugh Miser, accepted our proposed manuscript, poetry, colored pages and all. He promised that he would initiate IIASA's review and approval process on its behalf. At the time, Dana Meadows and I did not know (though Gerhart Bruckmann may have) that books published under IIASA auspices were subject to review by all of the twelve IIASA "National Member Organizations," primarily the Academies of Sciences of the respective member nations, before they could be submitted for possible publication. In addition, there were the review procedures of IIASA's publisher, John Wiley and Sons. With Miser's support, however, *Groping in The Dark* survived. Fortuitously, Wiley-Chichester, the Wiley division that reviewed our manuscript had published *Platform for Change.* Thus, what we expected might be a major impediment, publishing our book on pages of four colors proved not to be a problem.

*Groping in the Dark* appeared in 1982 and appears to have been a considerable success, though my evidence of this, too, is primarily anecdotal.[10] Moreover it helped empower me (and I believe Dana Meadows as well) to give greater priority to making our work accessible and not to shrink from publishing in formats and venues viewed as non-traditional by professional academics. In addition to lesson five (above) two additional ones from this life-changing experience have remained with me:

**LESSON 6.** ***Modelers studying similar problems whose work is framed by different paradigms may devote too much time to arguing about relatively arcane methodological differences and fail to emphasize points of consensus on more fundamentally important matters.***

**LESSON 7.** ***When considering how to make work you believe is important accessible, it is worth taking risks and affronting conventional wisdom. Sometimes, the results may pleasantly surprise you*.**

## Modeling the Linkages Between Conflict and Development

### Motivations for a new research agenda

Global modeling, and related global sustainability issues had been my preoccupation since that fateful day, in 1983, when Professor Mesarovic asked me to create a backup food and agriculture model for the Mesarovic-Pestel team's presentations at the Smithsonian and IIASA. With the publication of *Ending Hunger: An Idea Whose Time Has Come* and promotion of that book drawing to a close, the opportunity to initiate a new research agenda presented itself. I embarked a project for which I was, at the outset, singularly ill qualified. My goal was to develop a system-dynamics-model based theory that would answer the question: "***why are development assistance interventions that are intended to enhance human well being, so often followed by outbreaks of protracted violent conflict?"***

Two motivations impelled me. First, in collaboration with Professor Mesarovic and some other members of his team, I had consulted with the Shah of Iran's government on long-term development issues. Working with Iran's Plan and Budget Organization and with senior cabinet officials, including Prime Minister Amir Abbas Hoveyda, I had helped implement our models in an interactive format that would enable senior officials to examine consequences of alternative development scenarios in a global context. During Teheran sojourns, I had become conscious of what appeared to be a potentially volatile social situation created by a widening gap between rich and poor and an influx of young men from rural areas who had been attracted to the capital city by jobs in newly created industrial concerns. Prime Minister Hoveyda, who was later executed on orders from a revolutionary tribunal, was seated next to me at one luncheon event and I politely raised this concern. I recalled the Prime Minister's response when I later learned of his execution in a *New York Times* story that included a picture of an obviously terrified Hoveyda, surrounded by his guards. "We know our people," he reassured me. I wondered what role my work might have contributed to the revolution and turbulent scenarios that followed.

[10] I confess that I have not attempted to measure the our book's "impact." Google Documents lists 129 citations, which is considerable for conference proceedings, though much less that the citations listed for *The Limits to Growth and its Successor Volumes.* IASA has made the complete text available on its website (though without the colored pages) at http://www.iiasa.ac.at/Admin/PUB/Documents/XB-82-111.pdf.

My second motivation was broader. As a faculty member teaching "International Development" in American University's School of International Service to aspiring development professionals, I wondered about the degree to which implementation of the subject-matter we were conveying might be contributing to protracted violent conflict rather than human well being. As I began to search out relevant literature, addressing a subject about I had little knowledge, a third motivation began to emerge, which, retroactively, seems surprising in the post cold war, post 9-11 era. Conflict and development linkages had received little attention from either scholar-practitioners concerned with international development or those concerned with security. Three years into the project, I called attention to this gap in one of my early publications reporting model results, entitled "Violence and Repression Unexamined Factors in Development Planning" (1987),

With the assistance of a gifted research assistant, Deborah Milstead Furlong, research proceeded on two fronts, model development and identifying measures of conflict and repression (for which I used the less pejorative term, "state sanctioned violence) that could serve as reference-modes. After surveying relevant literature, we developed a generic model of conflict development linkages representing explanations of conflict based on psychological theories of relative deprivation that were popular among political scientists (e.g. Gurr, 1970; and ed., 1980). The model generated plausible reference modes in which the deprivations due to the volatility of economic performance in a hypothetical developing nation played a more important role than absolute levels of deprivation.

**Test cases: conflict and development linkages in Argentina and Mexico**

For the first test I chose Argentina, focusing on the period from 1900 through 1950 – later extended to 1980. Argentina's 20$^{th}$ century development trajectory had been characterized by both economic and political volatility, but it had not been significant protagonist in either World War I or World War II. I was seeking a country whose time-series data would not be disrupted by the war.

After a lengthy search through bodies of literature that seemed as contentious as the phenomena we sought to measure, we rejected various statistical metrics for measuring conflict and settled on a composite index based on an "events data" approach developed by sociologist Pitrim Sorokin. Among other cases, Sorokin had used his approach to measure conflict intensities in the Roman Empire. His work convinced us that the problems of data availability we were encountering were not insoluble. For "state sanctioned violence" (repression) we settled on an approach developed by Latin American Scholars James Duff and John McCaimant (1978), which used mostly qualitative data to index the intensity of state sanctioned violence for each month of the periods studied. Advantages of this approach were that we had an in-depth description of events in the reference mode trajectories we generated and they were based on data that was richly contextual. The down-side was that the data bases had to be created, *de novo,* for the countries that became the focus of the work: We compiled 80 years of data for Argentina and Mexico and 40 years of much more detailed data for Sri Lanka.

A detailed discussion of this lengthy project of more than twenty years duration, with output comprising two books and numerous papers (not all specifically model-linked) would extend well beyond the scope of this paper. Suffice it to say that it reaffirmed many elements of system dynamics theory and practice, not all of which comprise areas of agreement among system dynamics scholar practitioners. Here are a few highlights.

First the model demonstrated, as had the Lake Erie model, the value of a commitment to reproducing historical reference modes. As noted above, the first model juxtaposed a representation of Argentina's volatile economic development trajectory with a theory of conflict-development linkages based on relative deprivation theory. The model output did, indeed generate patterns of political instability, but the patterns bore little relation to the patterns that our laboriously collected data based on Sorokin's index revealed. Attempts to discover serious flaws in the way the theory was operationalized and parameterized in the model proved fruitless.

This lead to further explorations of the literature pointing to a second school of thought explaining conflict development linkages, political mobilization, that was, at the time, given little or no weight by relative deprivation theorists. Incorporation of this body of theory in the model, over an extended period of model refinement and testing, greatly improved model performance. This helped explain why the correlations generated by statistical analyses informed by relative deprivation theory were, while positive, so consistently low. It became clear that conflict could be a relatively spontaneous mass phenomenon evoked by volatile economic performance, resulting in feelings of deprivation that could create circumstances leading to sporadic outbreaks. But protracted conflict was the product of mobilization leading to the formation of groups with the resources and organization to sustain conflictual activities

Model experimentation also revealed the need for a third dynamic that incorporated elements of spontaneity – and elements of an epidemic or conflagration. Generating specific outbreaks of conflict required a stochastic mechanism (though the dynamic once an outbreak occurred did not). Thus we came to see conflict patterns that did occur seen as subsets of possible patterns that could have occurred. The best that the model could do was to show that the conflict trajectories our reference modes revealed fell within the ranges of those possible patterns.

The work also affirmed another principle of system dynamics modeling, that structure produces behavior. The model had reproduced possible conflict trajectories for Argentina (including a good representation of the trajectory that actually occurred) but the question of whether the same structure could generate very different trajectories that characterized a different case remained. Mexico provided a useful test because the conflict dynamic pattern it exhibited was quite different than that of Argentina. The ability of the model to reasonably reproduce Mexico's conflict trajectories further enhanced its credibility.

**Learning about conflict, terrorism and development from Sri Lanka's Civil Wars**

Originally my plan was to investigate conflict-development linkages in 10 countries, using my work on Argentina and Mexico as templates. I chose Sri Lanka as the third case study when an opportunity for a year-long visiting professorship at the University of Colombo became available in 1987. Distinctive attributes made this small island nation, formerly described in guidebooks as "paradise" a particularly attractive research site. For many years, Sri Lanka had been heralded as a development success story, a country that had achieved independence in 1947 without conflict, held regularly scheduled democratic elections that produced changes in governments and achieved relatively high levels of literacy and health despite only modest levels of per-capita GNP by global standards. Successful land reform and replacement of a Marxist-oriented government with one that voluntarily implemented free market reforms was also part of the Sri Lanka story.

After 1983, however, there had been rapid escalation of violent conflict, which, in ensuing years became protracted. In 1988, when my wife and I settled in Colombo for a one-year sojourn, government security forces were battling two militant groups. In the Island's North and East, a

Tamil secessionist force, the Liberation Tigers of Tamil Eelam, was fighting to establish an independent state. In the Island's south and some urban centers, Sinhalese militants, organized as the *Janatha Vimukti Peramuna* – JVP (People's Liberation Front) were seeking to supplant Sri Lanka's democratic institutions with a government based on a somewhat muddled philosophy incorporating Sinhalese nationalist, Maoist and Buddhist elements.

Products of my Sri Lanka research eventually comprised an edited volume, numerous papers and book chapters and a 700-plus page book, *Paradise Poisoned: Learning About Conflict, Terrorism and Development, from Sri Lanka's Civil Wars.* I chose not to formally apply the model to the Sri Lanka case, however. Instead, *Paradise Poisoned* situated explanations of Sri Lanka's conflict in the context of the island nation's political economic history. The previous modeling work, however, made two contributions.

A first contribution was that the model structure provided a coherent rationale, supplementing chronology, for organizing political-economic historical materials. Discussions of major periods in Sri Lanka's history began with a depiction of reference mode data on *patterns of conflict intensity*. A second section focused on *leadership and governance, emphasizing development policies*. A third examined the consequences of those policies and the degree to which they did, or did not contribute to *meeting people's wants and needs*. A fourth considered *political mobilization and the expression of organized dissent* (including the roles of political parties, religious organizations, labor organizations and, when they arose, militant groups). A fifth examined the degree to which government leaders' *responses to organized dissent* (non violent and violent) included *the use of state sanctioned violence*. In Sri Lanka, the nuanced examination of political feedback, in response to political leadership and development policies, was greatly facilitated by detailed constituency-by-constituency data, reporting the *results of regularly held elections* that were relatively free and fair.[11]

A second contribution of the modeling work was that systems dynamics theories emphasizing the relationship between structure and behavior played a key role in the explanations of conflict escalation in Sri Lanka that I view as *Paradise Poisoned's* principal findings. How the conflict intensity index developed by Pitrim Sorokin and the state sanctioned violence index developed by Duff and McCaimant were used to provide reference mode graphs for the Argentina and Mexico studies has already been discussed. The approached used to translate qualitative accounts of political conflict and state sanctioned violence in Sri Lanka into quantitative indices was similar, however my presence in Sri Lanka and the availability of a multilingual, multiethnic staff to help with data collection meant that a much greater level of detail was possible. The conflict reference mode was based on more than 5,500 conflict events that were recorded as narrative descriptions and then coded. The availability of narrative descriptions (all written out by hand in this pre-laptop era), meant that contextual details of particular events that the coding highlighted could be reviewed in considerable detail (including a return to the original sources for even finer detail if that was needed).

Basically the same approach was used to calculate monthly scores for state sanctioned violence, however the coding procedure differed in two respects. First the assignment of state sanctioned violence scores addressed issues of considerable sensitivity. The four dimensions of the index

[11] A volume compiled by the Director of Sri Lanka's National Archives, G.P.S.H. de Silva, *A Statistical Survey of Elections to the Legislature of Sri Lanka* (1979), was a unique, invaluable source. Dr. deSilva was kind enough to gift me a copy of his book when I first sought permission for my research staff to work at the National Archives. Later elections benefited from compilations by staff members of the International Centre for Ethnic Studies under the direction of my friend and colleague of many years, Dr. S.W.R. deA. Samarasinghe.

were (1) suspension of constitutional guarantees, (2) arrests, exiles and executions, (3) restrictions on the organization of political parties and (4) censoring of media. Different groups, including government officials and the police, could differ about how particular events were characterized. I decided to only allow my staff members to collect publically available news accounts and documents that were readily available for scholarly work. Whenever I described the project, I made it clear that my assistants played no role in classifying state sanctioned violence intensities. In fact, until *Paradise Poisoned* was published, more that fifteen years after the data collection was completed, I rarely discussed this aspect of the work. When I did begin speaking publically about the book in Sri Lanka, I constantly emphasized that this was a work of political economic history, through which I hoped those in other countries could learn from Sri Lanka's experiences. It was not in any way intended to be a commentary on current events, and, especially, it was not intended to offer political judgments or advice.

I can remember the excitement I felt when I viewed my first reference mode graphs depicting political conflict intensity in Sri Lanka. Refuting the view that recent conflict patterns were not fundamentally different than those of earlier periods, it demonstrated that violent conflict in Sri Lanka had been characterized by an order-of-magnitude qualitative change, following the violent "black July" riots of 1983. The riots had displaced more than 100,000 members of Sri Lanka's minority Tamil ethnic community. Many had died, sustained injuries or had their property damaged or destroyed.

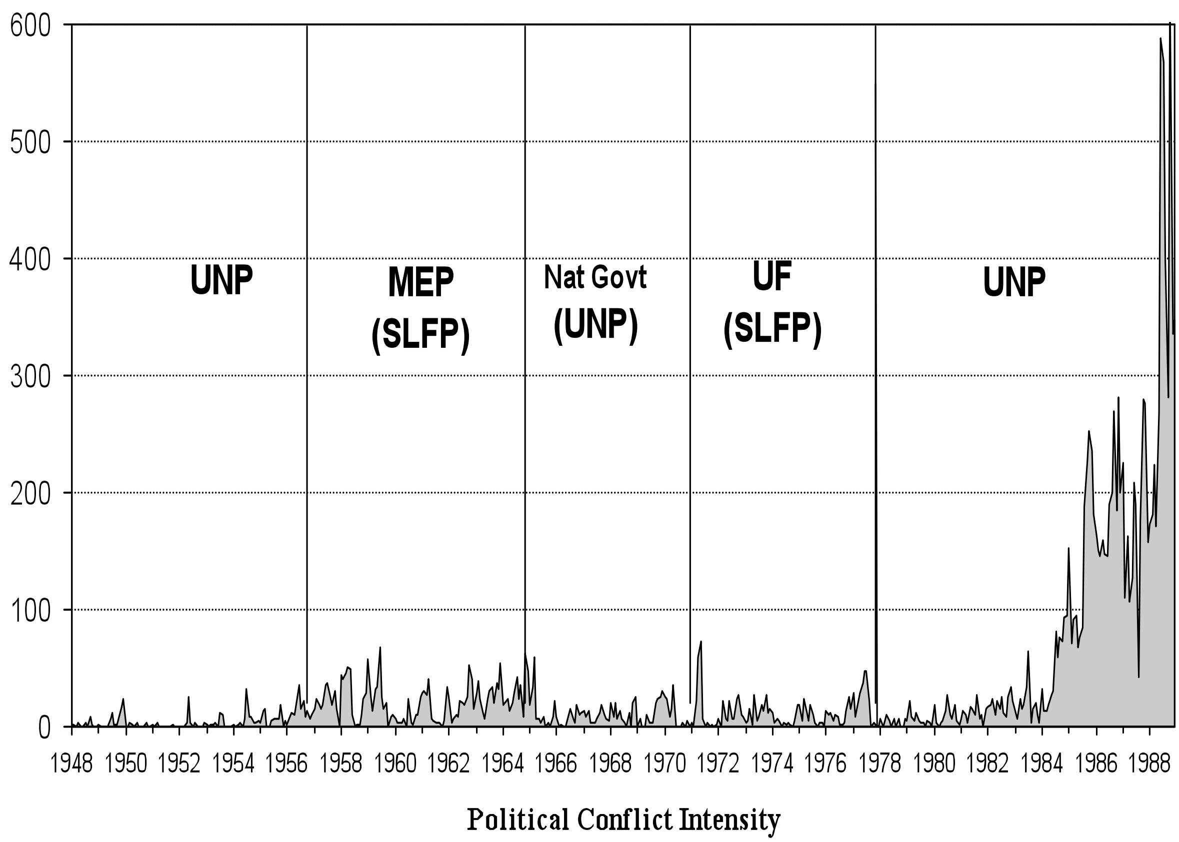


Figure 3. Political Conflict Reference Mode

In August of 1990, I used the occasion of the "G.C. Mendis Memorial Lecture," honoring one of Sri Lanka's most revered historians, to give my first major public presentation of research findings. The venue was Colombo's Bandaranaike Memorial Conference Center. The audience numbered more than 200 and included government officials as well as business, religious and academic community members. Security was high. This was a particularly turbulent time, with news of attacks and terrorist incidents involving both militant groups regularly appearing in the newspapers.

My lecture's title was "Understanding Violent Conflict in Sri Lanka: How Theory Can Help." Drawing parallels between "whole system" physiological theories underlying Sri Lanka's Ayurvedic healing practices and system dynamics modeling, I raised obvious questions to which the violent conflict reference mode pointed. Why did Sri Lanka's "immune system" perform so resiliently for so many years? Why, then, after 1983, was it overcome by the contagion of violent conflict?[12] Recasting the problem in system dynamics terms with a focus on relationship between structure and behavior, the questions of interest became these: (a) what was the system structure encompassing linkages between development and deadly conflict in Sri Lanka; (b) during the period that "the immune system" performed well, what negative (compensating) feedback loop or loops were dominant; during the period that violent conflict escalated, what positive (reinforcing) feedback loop or loops were dominant (c) what circumstances or events produced the shift in loop dominance.

**Structure and behavior: "The Development-Deadly Conflict System Model"**

The system structure (I used the term "model" colloquially to refer to this qualitative representation), was outlined in the Mendis lecture and more fully elaborated in *Paradise Poisoned,* Chapter 5. (See Figure 4.)

The underlying concept, owing a partial bow to Karl Deutsch's classic, *The Nerves of Government,* was that political economic institutions functioned as error controlled regulators that were designed to achieve the sometimes-complementary goals of meeting the needs of country residents and maintaining public order. But there were also a number of possibilities for breakdown, when the interactions of leadership/governance and economic structures/processes failed to deliver and failed to respond to public demands for change – or responded by seeking to clamp down on dissent. In such circumstances, rising discontent could manifest itself in spontaneous expressions of violent conflict, but also mobilization of groups with a militant agenda, which could give violent conflict a "staying power" that it otherwise lacked.

Paradise Poisoned argues that these dynamics can be better understood if the elements of the development deadly conflict system model are redrawn to highlight the somewhat different dynamics of three distinct categories of political-economic institutions that I label "Stable Democracy," "One Party State" and "Dictatorship." In each representation, negative or

[12] Crane Brinton's classic, *The Anatomy of a Revolution* (1965) provided my first introduction to the metaphor of violent conflict as a disease. Without using the terminology, Brinton even uses the concept of a reference mode, drawing an analogy between a hypothetical measure of conflict intensity and a graph plotted on a "fever chart" at the foot of an ill patient's hospital bed. The connection with Sri Lanka's Ayurvedic theories and practices was developed more fully thanks to conversation with Buddhist scholar and my friend of many years Bena Pieris.

compensating loops are shown which, when they are dominant, generate relatively stable system behavior. For example, in democracies, failure to respond to people's wants and needs results in feedback through relatively open channels of communication that produces changes in

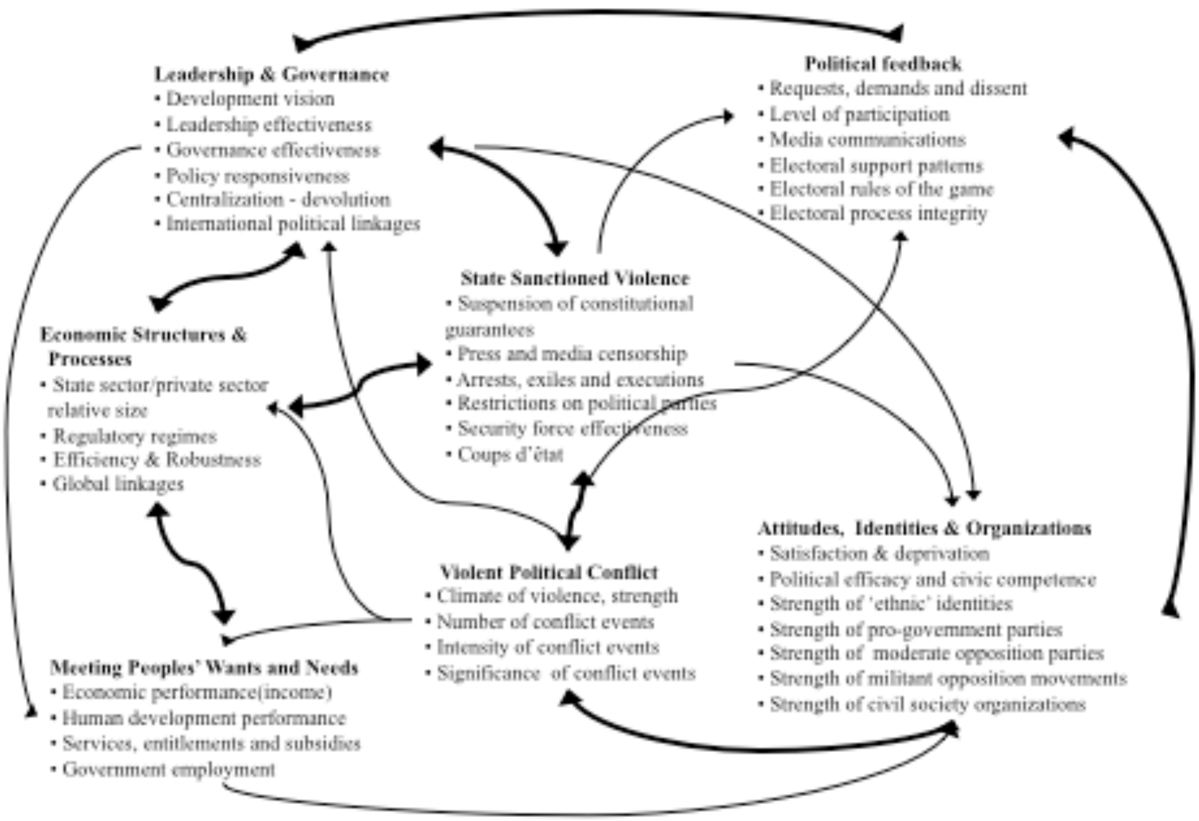


**Figure 4. Development – Deadly-Conflict System "Model"**

policies and, if poor performance persists, changes in leadership. On the other hand, changes in policies and changes in leadership do not guarantee improved performance. Political campaigns and elections do not necessarily elevate the most capable leaders to positions of power. They only guarantee that the policies of a new government and leadership cadre will probably be different that of its predecessor, not necessarily better.

The one party state seeks to seeks to "engineer" good economic performance (Ghesquiere, 2007) and the satisfaction of wants and needs by selecting leaders according to meritocratic principles and empowering them to design policies based on expertise. Dissent and expressions of dissatisfaction are not precluded, though the expectation is that responses will be via bureaucratic mechanisms leading to policy changes, but not by electoral ones that produce fundamental changes in leadership. Singapore, which is the focus of my present research and writing, provides a example of a system that functions quite well. China, too, seems to be functioning as a one party state with reasonable effectiveness and public support. But the one party state can also entrench ineffective leadership and policies that persist long after their ineffectiveness has been demonstrated. The attempt of Sri Lanka's late President J.R. Jayewardene to entrench a one party state model was a principal cause of escalating conflict.

The sole purpose of the dictatorship is to indefinitely entrench the position of whatever leader or leadership cadre that holds power. One of the interesting features of this type is that it can be quite stable. To cite three examples, Robert Mugabe's regime in Zimbabwe, the State Law and Order Restoration Council Military Government in Myanmar (Burma) and the Kim regime in North Korea have retained political control by empowering a draconian internal security establishment, while giving no attention (other than lip service) to meeting people's wants and needs.

**Explaining conflict escalation: how theory helped**

The rationale for this brief overview of the Development-Deadly Conflict System model is to lay the foundation for a result that emerged quite late in the completion of *Paradise Poisoned*. Having formulated the three political system representations, I was wanted to focus my attention on the destabilizing loops – the loops whose dominance, the representations suggested, produced escalating conflict. To my surprise, the loops were uncomplicated, and essentially the same for all three systems.

The first loop focuses attention on the domain of international development scholar-practitioners and policy agents. I label this *Conflict Escalation from Development Failures* (Figure 5).

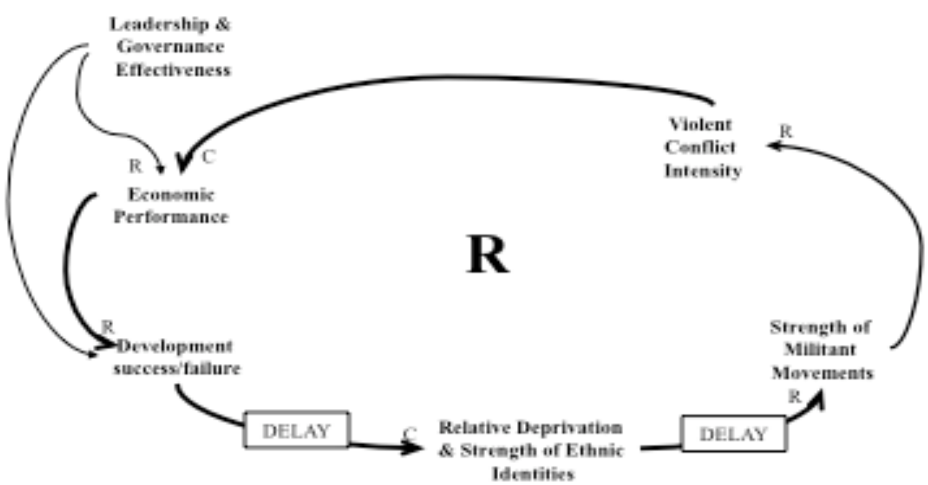


**Figure 5. Conflict Escalation from Development Failures**

3

When this loop comes to dominate, development failures contribute to feelings of relative deprivation, which facilitate mobilization, which increases the intensity and duration of violent conflict. This weakens economic performance, further degrading the development process. Policies that reduce development failures are the high level interventions that can reverse trends produced by this loop, but implementing such policies becomes increasingly difficult because of the adverse economic impacts that protracted violent conflict produces.

The second loop, Conflict Escalation from State-Sanctioned Violence Ineffectiveness, focuses attention on the domain of "national security" scholar practitioners and the security establishment – the police especially, but also the army, navy, marines, air force and paramilitaries. In many developing nations, internal security is the primary mission of military forces.

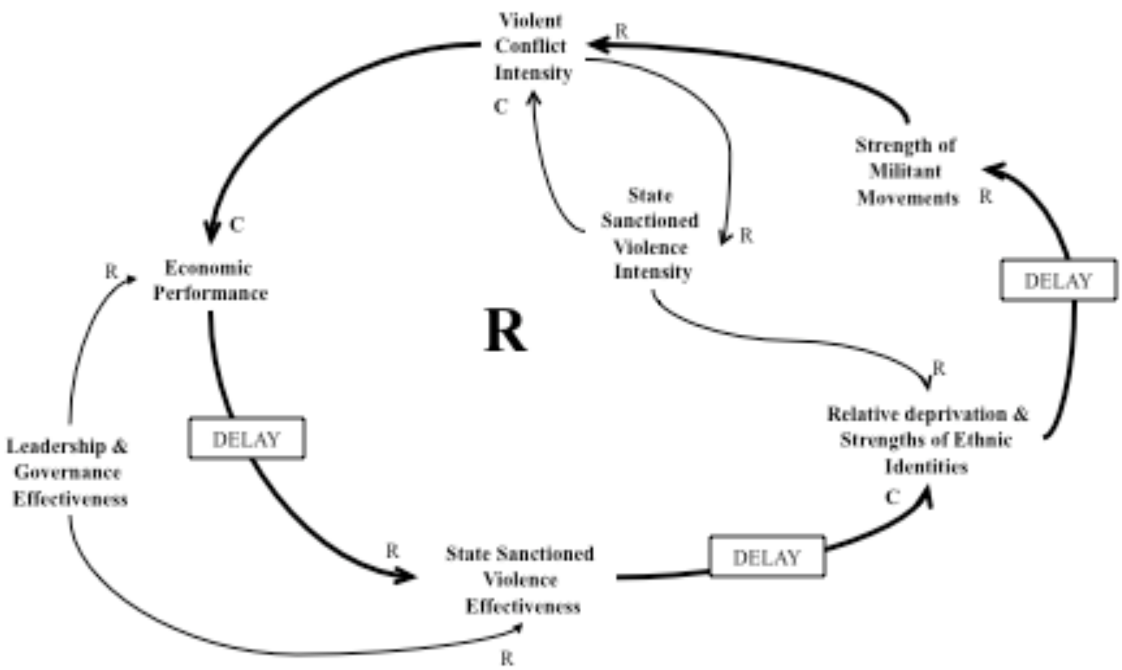


**Figure 6. Conflict Escalation from State Sanctioned Violence Ineffectiveness**

The agents of state sanctioned violence will be ineffective to the degree that they are under resourced, poorly trained, poorly lead and politicized. Corrupt and repressive security forces can provoke insurgency even in peaceful times. But violent conflict escalation due to development failures evoking state sanctioned violence that "pours gasoline on the fire" is the more common scenario, as it was in Sri Lanka for many years. Typically manifestations of ineffectiveness are an inability to subdue militant forces and in imposition of harsh measures and reprisals on broader populations. The problem is compounded, as it was in Sri Lanka, when the Security forces are members of one ethnic group and the forces they are attempting to subdue, along with a larger civilian population in a region, are members of another.

As many will have heard, after many years, a Sri Lankan government came to power that committed itself unequivocally to a military solution. The military forces were given sufficient resources and a clear mission. The corruption and political infighting that had weakened military capabilities and sapped morale were no longer part of the picture. Bad judgment on the part of LTTE leader Prabakharan had cost his forces their sanctuary in India and catalyzed a schismatic Tamil force that the supported the government. The resultant *Gotterdammerung* of Tamil Eelam resembled the final days of Hitler's Germany in many respects. But this outcome does not refute the validity of the Conflict Escalation from State Sanctioned Violence Ineffectiveness Loop. It affirms it, in fact.

**The role of the scholar; the role of the political leader**

Twenty-five years have elapsed since I first committed myself to seek a deepened understanding of the relationship between conflict and development, using system dynamics modeling. I have come to believe that dynamics and causes of violent conflict are much better understood than a review of literature that has proliferated since 1985 might lead one to believe. In particular, I believe that years of study and personal engagement with Sri Lanka have given me an understanding of that nation's conflict as well as possible paths to reconciliation and development. My familiarity with system dynamics modeling has contributed greatly to that understanding, though the phrases 'system dynamics' or 'system dynamics modeling' are rarely part of my public or (more frequently) off the record interventions. In Sri Lanka, I have had the gratifying experience of having my opinions sought out and heard with apparent respect, which does not necessarily mean they have played a role in shaping the policies of Sri Lanka's government or those of the US Government towards Sri Lanka. This is as it should be. I see no reason to alter the observation with which I concluded the G.C. Mendis Memorial lecture in 1990, at a much less hopeful time for Sri Lanka.

> Unfortunately, an understanding of the causes of violent conflict does not, in itself, provide a sufficient basis for implementing good policies and avoiding bad ones, though scholars sometimes believe this. Theory can help us understand the process by which violent conflict escalates. Promoting understanding is the role of the scholar. But effective political leadership requires a combination of understanding, toughness, vision, empathy, courage and the ability to communicate. Political leaders need the results of our theorizing. They need our understanding and our prayers as well.

The following are three lessons that I have gleaned from my study of conflict-development linkages.

**LESSON 8.** ***System dynamics modeling should not primarily be viewed as a simulation technique that is distinguished by its increasingly elegant graphical user interfaces and interactive model manipulation techniques such as sliders and gaming packages. The most significant value-added it provides is a powerful body of theory about the relationship between generic system structures and system behaviors.***

**LESSON 9**. ***The parable about a group of blind monks quarreling over their description of an elephant aptly describes the quarrels among social scientists about which explanation of conflict development linkages (and many other phenomena of interest) is "correct." A good system dynamics model can reveal connections between the elephant's extremities, but this does not mean that blind monks will resolve their quarreling.***

**LESSON 10.** ***A good system dynamics model may cast significant light on a problem's causes and even point to possible solutions. But, even when the modeler is respected and viewed as credible by senior government officials that does not mean his recommendations will be implemented or, if they should be, that the outcomes envisioned will ensue.***

## Coda: A Concluding Reflection

I should emphasize, once again, that the lessons presented here are not original to me. Their originality, if any, lies in particular stories and examples I have recalled that may help to highlight their relevance. Perhaps these stories and examples may empower my most important intended audiences, younger modelers and those yet to become modelers to reflect on my ten lessons and remember them as they pursue their craft.

When I am seeking guidance about modeling, both for myself and others, the source I still turn to more than any other is Donella Meadows and Jennifer Robinson's remarkable book, *The Electronic Oracle: Computer Models and Social Decisions.* I know this book well, not only from several readings, but also from seeing the manuscript piled on Donella's desk at Foundation Farm while her husband, Dennis, and other friends, including myself, nagged her to complete it. Finally, she did. The profession of modeling would be greatly strengthened if apprentice modelers were required not only to read this remarkable book but also to master its lessons. Here is an excerpt from Dana and Jenny's "Epilogue", which provides a more valuable concluding reflection than any I could write myself (1985, p. 438).

*We have said that computer modeling can add five important qualities to human understanding beyond what can be achieved by the mind alone.*

1. *Precision*
2. *Comprehensiveness*
3. *Logic*
4. *Explicitness*
5. *Flexibility*

*The great problems that threaten modern social systems – poverty and hunger, armaments and terrorism, environmental destruction and resource depletion – certainly would be helped if these five qualities became regular elements in human decision-making. But we have also said that these qualities cannot be realized unless modelers become compassionate, humble, open-minded, self-insightful, and committed. If <u>those</u> qualities would become regular elements in human decision-making the problems of the globe would certainly be solved.*

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