1st Note, bottom of page 150:

*These patterns were selected because they cover most of the dynamic patterns you are likely to encounter in environmental systems (BWeb).*

This statement can be verified by visiting the many model exercises on the BWeb. The pattern of behavior will match one of the six patterns in Figure 13.1

However, some systems exhibit surprisingly complex patterns of behavior. One example involves a combination of small and large oscillations which doubles the period of time required to see the cycles repeat themselves. In some systems, further changes can lead to another period doubling, so we would have to wait four times as long to see the cycle repeat itself. Mosekilde (1988, p. 27) explains a pattern in which small parameter changes can cause additional period doublings which eventually result in oscillatory behavior that takes forever to repeat itself. (The cycle has an infinite period!) This intriguing pattern of behavior is called “deterministic chaos.” “Chaos” refers to the apparently random nature of the oscillatory behavior. “Deterministic” refers to the ability of investigators to mathematically replicate the apparently random behavior with a deterministic model.

You may have learned about chaos and other intriguing patterns of behavior if you have read in the emerging literature in the field of “complexity” (Gleick 1988). System dynamics models are one of many tools to help in the study of chaos and complexity (Mosekilde 1988). Although chaos is intriguing, it is likely to be a “sparse and elusive” pattern of behavior (Andersen 1988, p. 7). It is more useful for an introductory text to concentrate on the fundamental patterns of growth and decay and the more common patterns of oscillations. Chaos and other topics from the field of “complexity” are more suitably addressed in an advanced text.

2nd Note, page 152, above Fig. 13.2, refers to the boom town situation

The boom town is a clear example of a socio-economic system where investigators do not have the option of performing controlled experiments. A short summary of the boom town model and a boom town analysis with explicit consideration of stake-holder values may be downloaded from the BWeb notes page.
Page 155 mentions examples in business and social systems. My favorite example deals with safety program at OSHA, the Occupational Safety and Health Administration. These programs aim to reduce occupational injuries through standards, inspections, and fines. They also provide information and technical assistance for managers and workers.

The effect of the programs can be examined by descriptive case studies, many of which conclude that programs are producing useful results. The programs are also evaluated with regression analysis. A frequent outcome is that the regression analysis shows ineffectiveness while the case studies argue that the programs are having good effects.

What should we conclude when the two approaches point in different directions? You might think that more study is needed, but McCaffrey (1985, p 198) observes that the conflict is normally settled in OSHA type situations by simply assuming that regression analysis is more reliable. McCaffrey challenged this conclusion. He called for studies which make use of a combination of descriptive analysis and regression analysis. This can be done with a combination of system dynamics modeling and synthetic data analysis. The system dynamics model relies on the information gained in the case studies, while the synthetic data generated by the model can be used to test the reliability of the evaluators’ approach to the regression analysis:

*The basic idea behind synthetic data experiments are, in principle, simple.*

*First, the simulation model .. is run a large number of times under varying conditions in order to create a large number of observations ... These observations are called “synthetic data.”*

*Because the structure and character of the model is known, the characteristics of the data generated by the model are known as well. Having produced the data, the experimenter ought to be able to design a regression model – relying on simultaneous equations, lagged variables, and variable transformations if necessary – to recover the known structure and parameters of the data-driven model.*

McCaffrey (1985, p 206-207)

McCaffrey demonstrated the value of synthetic data analysis to act as a bridge between descriptive case studies and regression-based evaluations. These approaches often yield conflicting results, and the conflicts should be studied in a careful manner that acknowledges the advantages of both methods. McCaffrey (1985, p. 212) demonstrated this approach with synthetic data studies in OSHA situations. The demonstration revealed that the limitations in regression methods could cause one to incorrectly dismiss effective programs. McCaffrey argued that synthetic studies should be launched in advance of regression analysis to avoid misleading results in the future.

Another example of synthetic data analysis is Peter Senge’s article on statistical estimation of feedback models. He used output from a working model to demonstrate the unreliability of commonly used statistical methods for estimating the parameters in a system dynamics model. His paper is mentioned at the bottom of page 153 in the book to help one understand why system dynamics modelers are wary of conventional statistical techniques (such as ordinary least squares parameter estimation).
A concrete example of synthetic data analysis with an environmental model is the “Extra Exercises” for chapter 15 (The Salmon Model of the Pacific Northwest). The model from chapter 15 may be used to generate results similar to data collected by fishery agencies. The commonly used measures of the health of the salmon population may then be simulated to learn if they provide a reliable measure of the actual health of the population.

For further reading on synthetic data analysis, see Andersen’s (1989) survey and discussion of research challenges.

References

Andersen 1988

Andersen 1989

Gleick 1988

McCaffrey 1985

Mosekilde 1988

Senge 1977
Peter Senge, Statistical Estimation of Feedback Models, Simulation, pages 177-184, June 1977