FUTURE takes
Transcultural Futurist Magazine
ISSN 1554-7744

Vol. 6, no. 3 (Fall 2007)

Book Review

Useless Arithmetic: Why Environmental Scientists Can't Predict the Future

by Orrin H. Pilkey and Linda Pilkey-Jarvis
Columbia University Press, 2007
230 pages
ISBN-10: 0231132123
ISBN-13: 978-0231132121

reviewed by Jay Herson

This seems to be a year to sell books that beat up on statisticians and applied mathematicians. As a statistician and a futurist I can appreciate these arguments but I still sit on the fence. This book is similar in spirit to Nassim N. Taleb's book *The Black Swan* reviewed elsewhere on this page, but where Taleb deals with the world of finance, this book deals with mathematical modeling as applied to environmental natural science problems defined broadly to include fishing, storing atomic waste, sea levels, beaches and coastal issues, acidic rivers and lakes, and invasive plants and species.

The book's take home message comes as a quote from Danish physicist Per Bak who wrote "Don't predict. Adapt." The authors feel that we are both prisoners and beneficiaries of our experience but this limits our ability to make predictions of the future that are of any value. They value qualitative models (futurist approach) over quantitative (mathematical prediction). For the latter the shear complexity necessitates that important variables are left out of models. Some of these variables are known by scientists and some variables and events are unknown. In qualitative models only the direction of change is predicted, not the precise numerical quantification of change. Moreover, quantitative modelers are guilty of not evaluating the accuracy of their models over time, finding shortcomings, reporting them to the public and revising the models. However, the policy makers and the public like numerical results because of the feeling that they are more precise than qualitative models.

In the case of fishing policy for allowable catches, with cod fishing in Canada as the principal example, the authors contend that modelers concentrate on single species and ignore effects on the entire marine ecosystem and that some modelers know their predictions are inaccurate but use them to convince politicians of funding levels and to reduce pressure from politicians and recreational fisherman.

For Yucca Mountain predictions of atomic waste disposal, the authors attack models for even claiming they can predict what will happen tens of thousands of years from now due to the huge time span covered by the models, lack of knowledge of the role of time in chemical reactions and degradation of waste containers, uncertainty of climate change and complexity of the natural processes involved. Models have been accepted because of the need to come up with a rational solution soon. They authors contend that an alternative would be at least to predict for a shorter period of, say, 200 years, and then use adaptive staging meaning to predict for another 200 years based on what has been learned in the previous 200 years and so on.

In the area of beach erosion, the authors provide a long list of variables that have been ignored by quantitative modelers and indicate the role of "black swans" in this field. When models fail predictions, the modelers blame "unexpected" storms as the reason for failure. Just as Taleb would claim the authors point out that these black swans are not so unusual at all and must be considered in some way. This is another field where people with a vested interest use quantitative models that they know are wrong or severely limited – to make a point to policy makers who are eager for the presumed precision of the models.

Ground waters at the site of abandoned mines can become acidic over time due to the open pit mining process. Models have continuously failed and government agencies that promote mining also regulate mining giving them a conflict of interest and a reason to accept positive predictive models. While the consequences of an unfavorable model can be disastrous on the stock price of a mining company, there are no consequences for a mistaken model itself.

Modelers have failed in risk assessment for invasive species of plants and animals on local ecology. Surprisingly biological scientists have realized the shortcomings of quantitative models imposed on them by engineers. They point to "black swans" such as the impact of African dust as a source of pathogens in South Florida and expansion of Johnson grass from the subtropics to the subarctic. These factors in addition to human behavior have been unexpected but not unusual in their effects on ecology. These biological scientists have turned to qualitative modeling as a solution.

In a concluding chapter, the authors rate modeling for beach and coastal issues to be the worst and those for global sea change and invasive plants to be among the best used. The latter pass muster because qualitative models have been accepted here. Errors in characterization, omission of important processes and ignoring the possibility of black swans are the principal reasons for failure of quantitative prediction. Alas, the authors indicate that qualitative models using the futurist tool of scenario creation are the best method for environmental policy making. They advocate making scenarios that cover a range of outcomes – bad outcome, continuation of current trend, good outcome – and make contingency plans for each. This approach would be called adaptive management, which the authors advocate for Yucca Mountain and for fishery management. Scenario planning can exploit uncertainty, is compatible with long term planning, and can allow for multiple answers and black swans.

Environmental health readers may be disappointed that the book does not cover modeling of air pollution or drinking water supply and quality. Although their arguments are convincing even to a practicing statistician, the authors think it necessary to abruptly leave the field of earth science to bring in Taleb's *The Black Swan* example of the failure of derivative modeling by Long Term Capital Management due to the impossibility of predicting human behavioral response to economic trends. It is not clear why this example was needed. The quantitative horse was already dead.

This book is useful to the general reader to understand the pitfalls of quantitative modeling and introduce them to scenario planning and adaptive management.

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POINTS FOR THE CLASSROOM *(send comments to forum@futuretakes.org)*:

- *According to the reviewer, the authors feel that because we are prisoners (as well as beneficiaries) of our experience, this limits our ability to make predictions of the future that are of any value. One example of this is the historical tendency of nations to prepare for the most recent war instead of for wars that may happen in the future. Furthermore, people tend to interpret events in terms of their past experience. In addition to qualitative models, how can people – especially futurists – transcend that limitation?*

- *Is the need for a "rational solution soon" universal among nations and peoples, or is it more prevalent where thinking is "reductionistic" than where it is holistic? In answering this question, consider national and regional demographics, particularly in regard to professions.*

- *The authors present an "adaptive staging" approach that uses modeling in increments – for example, 200 years in the case of nuclear waste disposal. Do you anticipate that this approach will be a preferred one for futurists, and for policy makers, in 2020 – and if so, for which applications (considering the present limitations of some models, e.g., economic, meteorological, that often focus on shorter timeframes)?*

- *By 2020, will there be a resurgence of interest in qualitative methods among policy makers who do not favor such methods now?*

- *In your favorite field of study or interest, what are the key variables that models fail to consider?*

- *Also see related "Points for the Classroom" in book review of* The Black Swan*, this issue.*