Everyone Was an Environmentalist

Highlighting an environmental statistician: David R. Brillinger

Everyone of my generation growing up in Canada, rich or poor, was an environmentalist. The lumber and natural resources produced the country's wealth. Many worked on farms in the beautiful outdoors. In the summers the people of the large cities, Montreal and Toronto, fled the heat and humidity, perhaps to tiny cottages not directly on a lake or perhaps to an island or lake only for a weekend day, but they got outside. People were proud of Canada's great outdoors.

From my earliest days I was swimming, sailing, camping. At the same time I was learning the names of countless birds, animals, trees and the like–learning to respect the environment. It became part of my soul. Once, in those early days, when I was on a lengthy canoe trip in Timagami we passed through an area that had been burnt over by a wildfire. There was no green, no birds and no sound. I was in awe. The same things happened later with the acid rain crisis. Those are the beginnings of my journey into environmental statistics.

My undergraduate degree at the University of Toronto was in Pure Mathematics and D. A. S. Fraser there diverted me from the road to an intended career as an actuary. He encouraged me to go to Princeton as a stage in becoming an actuary. At Princeton I was charmed by John Tukey. Fairly quickly JWT had me preparing and running time series programs for analyzing records of earthquakes and explosions. This was a period when he was a member of the U.S. scientific delegation seeking to develop a nuclear testban treaty. One of the basic questions was whether it was possible to distinguish an underground test explosion from an earthquake. (The answer was "Not yet.") My work with earthquake data continues to this day and perhaps my actuarial roots show up in my periodic focus on seismic risk.

I was a Member of Technical Staff at Bell Telephone Laboratories from 1962 to 1964. The work on earthquakes and explosions continued there, but other environmental data sets were being studied, for example data collected by early satellites. Even more important to my growing as a statistician there were Martin Wilk, Ram Gnanadesikan, Colin Mallows, Bill Williams, Roger Pinkham and Dick Hamming to learn from. Lunch time was a statistics/data analysis course at the highest level available on the planet.

Next I was at the London School of Economics from 1964–1969. There I continued to work on seismology, consulting with the British group at Blacknest developing seismic array analysis, again as part of the bomb versus earthquake problem. The data were spatial-temporal as is much environmental data. In those years it was near impossible to work on methods for exploratory time series analysis without being drawn to environmental data–that was where the data were.

If I may go back to John Tukey, with whom I kept in fairly regular contact through the years, he was one of the most, perhaps the most influential environmental statistician in the 60's and 70's.He was on Presidential Commissions. The proposition of one, [14], was that polluters pay for their emissions via taxes. It further affirmed no right to pollute. The work of this commission was motivated by Rachael Carson's book, T*he Silent Spring*. There were other commissions as well, [15], [16], [17]. Tukey was a Member of the US Delegation to the U. N. Conference on the Human Environment in 1972.

Historical temperature data for various European cities were the continuing worked example in my book, Time Series: Data Analysis and Theory (1975). These data, dating back to the 1700's, came from J. M. Craddock of the British Meteorological Office. Sunspots, rainfall, environmental and geophysical data generally became my testbeds for linear and nonlinear time series techniques.

In 1970 I came to Berkeley and fell under the spell of Jerzy Neyman. He was a major player in the then hot topic of whether cloud seeding actually worked, [11]. (The simple answer is still "We don't know.") For me it was a move from a mentor who had little use for formal models to an equal giant to whom specific assumptions and models were of the essence. Professor Neyman worked hard on statistical formulations of problems of pollution, particularly carcinogens, [12]. His Wednesday Seminar had many speakers on environmental topics. In 1975 Elizabeth Scott and I organized a conference on forecasting pollution for the California Air Resources Board, [8].

At Berkeley I learned that there was more to seismology than time series, specifically there were point processes. (Actually I had been tipped off to this a bit earlier by David Vere-Jones and his influential RSS Discussion paper.) At Berkeley I worked and sailed regularly with Bruce Bolt, then Director of the Universities Seismographic Stations. Seismic risk was a continuing conversational topic. I further had the privilege of "supervising" Tore Schweder's highly influential 1975 thesis [13] on whale statistics.

In 1977, Tukey pulled me from being an observer of the cloud seeding controversy into participating. He chaired a committee with Lyle Jones and myself as members concerned

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with the question of whether rainfall had actually been increased in a cloud seeding experiment. A report, [5], was drafted at various locations across the country. Actually it was Volume II. Volume I contains the comment that statisticians too often hear, "At some points, the Board may have drawn general conclusions about the status of a given form of weather modification that differed from the statistical findings." Hmmmh.

In the early eighties I came under the influence of two other charmers, Hilgard O'Reilly Sternberg and Abdel El-Shaarawi. Hilgard is the world's expert on the geography of Amazonia while Abdel created the International Environmetrics Society (TIES), and the journal *Environmetrics*. Further he was co-editor of the recent *Encyclopedia of Environmetrics*.

Hilgard and his wife came to me one afternoon with an amazing series that they had put together namely daily levels of the Amazon River at Manaus, Brazil going back to 1903. They further came with a question. (For once I didn't have to ask, "What is the scientific question?") The question was–is there evidence that more floods are occurring? Hilgard said that they were bound to as some point in time because of all the deforestation taking place, [10]. (The answer to the question was "Un soupçon."

Abdel got me to join TIES, got me to do editing and co-editing and invited me to give talks at various TIES meetings on environmental topics of my choice. He further involved me in a NASA Committee concerned with the statistics of space debris, [1]. Luckily for us statisticians, NASA had considered this to be a problem for researchers in environmental statistics.

Another individual who pulled me into work on an environmental problem is Brent Stewart a researcher at Hubbs Sea World. He was one of the organizers of a workshop at the University of Fairbanks on what to do with all the data on seal journeys that was being collected. There were equal numbers of statisticians and seal experts at the workshop and the interactions were highly productive. (Workshops are surely the way to go for creating inter-field interactions.) Brent fed me data sets and we wrote a number of papers together, [9].

The analysis of wildlife data continued with work with researchers at the U. S. Forest Service (Haiganoush Preisler, Alan Aager, and John Kie) on modeling the tracks of elk via stochastic differential equations, [6]. More recently there has been work with Haiganoush Preisler and John Benoit on the estimation of wildfire risk, [7]. Also I hang out with the Berkeley civil engineers a lot. Many, perhaps most, of their problems seem to be environmental.

I am not sure whether time series or environmental problems came first, but it seems that one can't work on one without being involved with the other. The continuing statistical methodology involved has been that of spatial-temporal processes. Nowadays is a super time for research and development of the subject of environmental statistics with all these environmental data sets so readily available on the web.

Where has all this reminiscing led? The question that the Editor put to me was something like, "Would you write about what led you into environmental statistics?" It is clear from the above that particular individuals and problems they suggested played crucial roles. I have had wonderful role models and collaborators.

There follows a selection of papers of those who influenced me strongly and some of my own.

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