The grounding of the Exxon Valdez on Bligh Reef in Prince William Sound in March 1989 ranks as a disaster of the first order, the largest oil spill in US history. Eleven million gallons of North Slope crude dumped in one of the most beautiful places on Earth cannot be easily overlooked or ignored, and it was not. Nor did it take long to choose sides in what became a long-running and costly collection of activities called NRDA (for Natural Resource Damage Assessment). The sight of heavily oiled and dead sea birds and otters on the evening news, televised live from Prince William Sound, overwhelmed all human efforts to explain or contain the damage, including the public relations damage hapless oil company and bewildered government officials heaped on themselves. In the media contest between sea otters and Texas oil flaks or gray government bureaucrats, otters win every time.

Oters may have won the media contest, but some fear that scientists may have lost their innocence and science its credibility. Of one thing there is little doubt, the true winners overall are the lawyers, whose numbers are seemingly only exceeded by the black flies of summer.

Lawyers needed facts to support claim and counterclaim, and most of those facts revolved around the harm done by so much oil being dumped in such a lovely place. There was no dispute about the fact of oil in Prince William Sound—lots of the awful, stinking stuff—although assigning blame and figuring out why it got there required legal recourse and eventual penalty. In these pursuits, the facts required were often, if not primarily, scientific, and NRDA was a primary means to secure them.

This book assembles much of the marine mammal work done directly under NRDA. Some 40 marine mammal specialists from Alaska and elsewhere are featured in this collection, edited by Thomas R. Loughlin of the National Marine Fisheries Service's Marine Mammal Laboratory in Seattle, Washington. This book is most welcome for several reasons, not the least being its assembly in one place of perhaps the most extensive set of references on its stated topic. Nonetheless, the damage assessment went well beyond marine mammals to include monitoring, cleaning up, and mitigating activities and their consequences for terrestrial mammals, birds, fish and shellfish, and their habitats, including the entire ecosystem centered on, but not limited to, Prince William Sound. NRDA was huge, and this book concentrates on but a small part of it.

Two concise opening chapters give adequate context to the discussion of mammals within the larger whole of the Exxon Valdez spill and its aftermath (up until approximately 1993). Readers wanting to know more about the legal and political institutional details are well advised to look elsewhere. The true purposes of this book are to highlight and detail marine mammals from various scientific angles. Chapters such as "Pathology of Sea Otters" (chapter 16), "Impacts on Distribution, Abundance, and Productivity of Harbor Seals" (chapter 6), and "Tissue Hydrocarbon Levels and the Number of Cetaceans Found Dead after the Spill" (chapter 20) suggest the approach and style of the book.

For the nonspecialist initially attracted by the book's compelling title the going could get rough. The conclusions reached and lessons learned could be less than edifying as well.

Sea otters died, to be sure. But how many? We know how many were captured and cleaned up: 343, approximately half of which died in captivity, and some of which died after release. Based on modeled esti-
mates, the otter loss may have been 2800 killed (p. 78), or somewhere between 3500 and 5500 otters from a total population of about 30,000 in the Prince William Sound and the Gulf of Alaska may have died as a direct result of the oil spill” (p. xiv). The numbers are not precise. A consistent rationale for basic measurement problems was the lack of adequate baseline data from the pre-spill setting—a finding resulting in a call for “rigorous survey protocols in areas shared by sea otters and oil recovery, storage, and transportation” (p. 94).

The mortality figures and the causal connections between oil and other marine mammals are even less well grounded or defined than for otters, which makes damage assessment problematic. For instance, “None of the data presented and analyzed provided conclusive evidence of an effect of the Exxon Valdez oil spill on Stellar sea lions” (p. 137). Or, with respect to the killer whale groups or pods resident in Prince William Sound: “It is not clear why six resident pods, other than AB, have increased from 86 whales in 1984 to over 100 whales in 1992” (p. 159, emphasis added). Or for humpback whales: “The results of this study do not indicate a change in abundance, calving rates, seasonal residency time of female-calf pairs, or mortality” (p. 188).

So to what does all add up? The final chapter, by D. J. St. Aubin and J. R. Geraci (chapter 21), tries to be responsive but comes up short with solid conclusions or hard recommendations, once again, save the expected call for more research: “It is apparent from the studies presented in this volume that good baseline data yield better answers sooner—a reminder of the value of ongoing studies into fundamental biological questions” (p. 375).

Under the circumstances a key question remains: Does good baseline data exist to judge the effects of the coming Newt-on bomb on biology and biologists?

GARRY D. BREWER
School of Natural Resources and Environment
University of Michigan
Ann Arbor, MI 48109-1115

ACID RAIN IN NORWAY

Through the long public and scientific debate, mostly in the 1980s, on effects of acidic deposition, everyone seemed to be looking for the one critical experiment that would clearly support or reject hypotheses about acidic deposition and damage to forests. Even in areas of profound damage, as in the Black Forest of southwestern Germany, the presence of factors unrelated to acid, such as the high level of oxidants, left doubt as to whether reduction in acid gas emissions would relieve the damage. Millions of dollars were spent testing hypotheses by reproducing in enclosed facilities aspects of the growth and cycling of materials from a forest ecosystem. However, no one was ever sure that the results from these separate experiments were capturing the reality of a mature forest ecosystem as it functions in the field under the stress of acidic deposition.

The only serious alternative approach seemed to be to study directly what long-term changes were taking place in the field, supplemented by experimental human manipulation of acid inputs. The Norwegian Ministry of the Environment, the Agricultural Research Council of Norway, and the Norwegian Forest Research Institute undertook such a study in the late 1970s and early 1980s. Norway had been a leader in comprehensive, interdisciplinary studies of acid rain effects on aquatic ecosystems and adjacent forest uplands during the 1970s. This work led to other large-scale forest surveys and multiple small-plot or watershed studies of acid-base relationships in forest soils starting in the late 1970s. Some of these experiments used acid additions by spray watering, mostly between 1972 and 1978 (with a few extending until 1983). When relatively large-scale damage became evident in mid- to high-elevation spruce forests in Germany during 1983, the Norwegian government approved increased funding for subsequent monitoring of these experiments and coordinated detailed process research at many sites.

The book Long-Term Experiments with Acid Rain in Norwegian Forest Ecosystems, edited by Gunnar Abrahamsen, Arne O. Stuanes, and Bjørn Tvelte, is a summary of the results up through 1988. As such, it may come as close to being a report on the ideal so-called critical field experiment as is possible.

One strength of the book is the systematic design by which large-scale field experiments were carried out, monitored, and reported. The only comparable study that comes to mind is the watershed manipulation done as part of the Hubbard Brook study in New Hampshire. The latter was more focused, because it was one site, and simpler, because there was not an ongoing manipulation of all the sites as there is when field studies of the effects of acidic deposition are undertaken. Thus, considering the need to investigate multiple types of forest/soil systems and the changes already taking place (ameliorated on some plots by lime treatments), this book is important for the experimental approach as well as for the results.

Perhaps the most conclusive findings are in a 64-page chapter on soil chemistry. Here, extensive survey charts show the gradual decline in soil pH, base saturation, and exchangeable calcium and magnesium in the B horizon layer of most of the acid application experiments. However, trends were not consistent for cation exchange capacity. Interestingly, however, the results show that the acid additions increased (and lime additions decreased) the organic matter in the surface soil horizon, thereby changing cation exchange capacity inversely to what is commonly expected following acid treatments. No discussion is offered in the text as to the importance of the so-called consistency in what is judged to be an inconsistent result.

The chapters that follow focus on soil biology (plant and animals), with interesting results on the effect of the treatment water pH on the

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