Science's

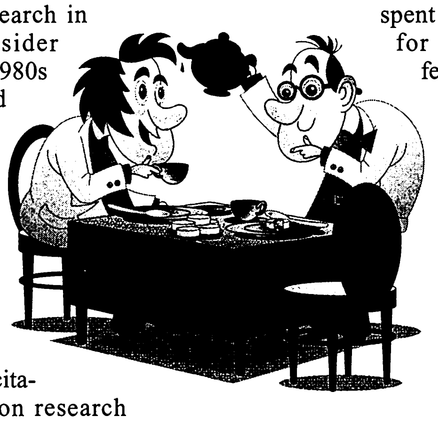
COMPASS

LETTERS SCIENCE & SOCIETY POLICY FORUM BOOKS *ET AL.* PERSPECTIVES REVIEWS

British Science: A Toast to Teatime

IN 1831 A FRENCH ARISTOCRAT NAMED Alexis de Tocqueville spent several months touring the United States, ostensibly to study the prison system. The young nobleman's true intent, however, was to observe the new experiment in government, with the hope of exporting some of its strengths to his native land. Today, his resulting treatise, *Democracy in America* (*1*), is a classic on both sides of the Atlantic.

Unlike Tocqueville, we Americans are often reluctant to learn—or even to admit there is anything to be learned—from other nations. But this narrow perspective ignores potential strategies for growth and improvement. As scientists, for example, what can we learn from the approach to scientific research in other cultures? Consider British science. In the 1980s to mid-1990s, the United Kingdom consistently led many more populous countries in total number of papers produced and citations received per paper in science, medicine, and engineering. Indeed, publications by British researchers received more citations per pound spent on research than papers from nearly all other countries, including the United States. During the 20th century, the United Kingdom won more major international scientific prizes per capita than any other nation—about 10% of all such awards (*2*).



Many explanations have been proposed for this success. Some British, perhaps only partially in jest, attribute it to an inherent superiority of intellect and character. Yet British scientists are a more elite group than American scientists, due to selective pressure throughout secondary and undergraduate education. My experience in the United Kingdom leads me to think that another significant reason for this success is the British style of scientific investigation. I must admit that at first I was frustrated by the slower pace of research in the United Kingdom in comparison with that in the United States. Having recently completed my doctoral research in the intense environment typical of many U.S. universities, I thought that the greater relative emphasis that the British placed on thinking rather than doing was at best misguided, and at worst, lazy. However, I soon saw the advantages of being more selective about which problems to work on, which experiments to perform, and which approach would best interpret the results.

In general, my new colleagues were less hurried, more accessible, and, in stark contrast to the stereotype of the reserved Englishman, friendlier. They shared their ideas and time and were less competitive. They showed a genuine interest in the research of others, and often took time to attend a seminar on a topic far from their own research. Senior scientists spent less time applying for grants, managed fewer people, and often conducted experiments themselves; I encountered fewer of the out-of-touch administrator-scientists that I had met so often in the United States. The resulting workplace environment translated into increased enthusiasm and productivity for almost everyone. Miserable postdocs seemed to be the exception rather than the norm.

The British approach to research is embodied in the daily ritual of afternoon tea. At British universities, it is customary to cease work and spend a half-hour or so sipping tea and eating cookies with the members of one's department. Conversation ranges from science to politics to personal chitchat. I found that the professional benefits of teatime more than compensated for the time spent away from the bench. Not only was I the recipient of many insightful suggestions and ideas, but simply by explaining my latest results to someone outside my field and answering his or her questions, I was forced to think about my work in a broader context. Relationships were built that were later drawn upon for advice, collaboration, and friendship.

The characteristic approach to scientific inquiry in a country has many complex and interdependent causes, as does any cultural difference. The British selectivity about which experiments to perform, for example, is due as much to personality and temperament as to fewer personnel and fewer financial resources. But I also believe that another important determinant of research style is learned behavior—passed down from mentor to student and contagious among colleagues. Thus, while no one can claim that the British approach to research is perfect or deny that the American approach has been successful, perhaps we can learn a few lessons from our colleagues across the pond—take time to think about the big picture, share ideas, stop for tea…have fun.

The percipient Tocqueville wrote, "America is a land of wonders, in which everything is in constant motion and every change seems an improvement" (*1*). Perhaps we American scientists should take his words not as congratulation, but as exhortation.

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Factors in the Decline of Coastal Ecosystems

IN THEIR REVIEW "HISTORICAL OVERFISHING and the recent collapse of coastal ecosystems," Jeremy B. C. Jackson and colleagues argue for the "primacy" of overfishing in the collapse, in contrast to pollution, species introductions, climate change, diseases, and other human impacts (special issue on Ecology Through Time, 27 Jul., p. 629). They suggest that overfishing had the earliest im-

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pacts and was a necessary precondition for the occurrence of other maladies. Although we agree that fishing has contributed to major changes in coastal ecosystems, we believe Jackson and co-authors overstate the case for its primacy. The overfishing and nutrient pollution of coastal seas, for example, have frequently proceeded simultaneously and contributed to degradation synergistically (*1*).

In Chesapeake Bay, as the authors point out, the process of eutrophication began with land clearing in the 18th century, well before the mechanized harvest of oysters in the late 19th century. Although most of the filtration capacity of oyster populations had been reduced by the 1930s, the dramatic intensification of hypoxia and the extensive loss of seagrasses occurred later, during the last half of the 20th century, associated with a more than doubling of the already elevated nitrogen loading (*2*).

Recognizing that rebuilding oyster populations could help to mitigate planktonic overproduction due to nutrient pollution (*3*), the multistate Chesapeake Bay Program has established the ambitious goal of a 10-fold increase in oyster biomass. But restoration of oysters even to precolonial abundances is unlikely to eliminate algal blooms and hypoxia and recover seagrasses without also significantly reducing nutrient loading. Decreasing bottom-up stimulation and increasing top-down controls will be required.

Although the degradation of oyster reefs by overfishing might have made oysters more susceptible to endemic diseases, a particularly virulent pathogen (*Haplosporidum nelsoni*) was introduced from a nonindigenous oyster host in the 1950s (*4*). This introduced disease now greatly limits the ability to reestablish oyster populations.

Similarly, it is not likely that intact populations of large consumers, such as green turtles and sea cows, would have prevented the deleterious consequences of nutrient pollution, sedimentation, and other human-induced stresses on tropical seagrass ecosystems witnessed in the late 20th century in such regions as Australia (*5*) and Florida Bay (*6*). And there were no similar large consumers of temperate seagrasses, which have also undergone decline. Regardless of the historical sequence of human stresses, amelioration of multiple stresses must take a multi-pronged approach to restore coastal ecosystems.

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Response

OUR REVIEW IS INDEED ABOUT THE DEEP historical roots of human degradation of a diverse suite of coastal marine ecosystems, caused by and preconditioned by fishing exploitation and attendant damage to biogenic marine habitats. The novelty of our study lies in its use of multiple associated disciplines, such as paleontology, archaeology, governmental record analysis, and maritime natural history, to provide ecological baselines of the past that long predate the formal discipline of ecology, as it can be traced to Elton, Lotka, Park, Birch, and other early 20th-century founders. Synthesis of such historical information for a variety of coastal marine ecosystems revealed a large impact of fishing and sea hunting that generally predated other human impacts, independent of the system.

Harvesting oysters from Chesapeake Bay.

CREDIT: JAMES LAMOS/CORBIS

If our review can be construed as arguing that restoring the overfished species and habitats degraded by fishing would be sufficient in themselves to counteract the deterioration of coastal marine ecosystems, we apologize. No amount of success in restoring the sharks and sea turtles to remote coral reef ecosystems, for example, will counteract the growing impacts of coral bleaching induced by global warming and other physical causes. Furthermore, we concur that reduction in nutrient loading to the world's estuaries and coastal seas is a critical component of management strategies to restore lost ecosystem services and reverse eutrophication.

Likewise, if our narrative implies that fishing acts independently of other stressors, we welcome this opportunity to reject such an interpretation. The synergistic interaction among multiple factors is the essence of our argument that impacts of historical fishing preconditioned many coastal ecosystems to subsequent collapse when later stressors were applied. For example, the reduction in height of subtidal oyster reefs through incremental mining of shell matrix by dredge fishing in Chesapeake Bay and Pamlico Sound interacts with oxygen depletion of bottom waters (*1*) and exposure to oyster disease (*2*) to influence oyster health. Additionally, restoring the extent and stature of oyster reefs in Chesapeake Bay and other bays worldwide is likely to restore substantial levels of water filtration—even if oyster life-spans are still shortened by disease—because these reefs provide the unique hard substratum not only for the rapidly growing juvenile oysters, but also for other epibiotic filter feeders like tunicates (*3*). Oyster reef restoration must be valued for ecosystem services to water quality and estuarine habitat, even if restoration of traditional oyster fisheries is also a goal over a longer time frame (*4*).

We prepared our review not to deny the impacts of other human activities on marine ecosystems but rather to document and emphasize the significance of fishing impacts upon apex consumers, critical biogenic habitat engineers, and important grazers that occurred so far in the past as to be often forgotten and ignored in restoration plans. Human-induced extinctions in the marine environment have lagged behind those of terrestrial ecosystems, so there still exists the biological potential with which to rebuild coastal marine ecosystems. We need to recognize these historical fishing impacts to appreciate the importance of apex consumer and grazer restoration in our integrated plans.

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People and Biodiversity in Africa

GROWING HUMAN PRESSURE ON EARTH'S biodiversity demands rapid development of a sound scientific and economic foundation for conservation. Andrew Balmford and coauthors, in their report "Conservation conflicts across Africa" (30 Mar., p. 2616), say that their analysis of African diversity patterns contradicts my earlier analysis and proposal for reconciling some of the conflicts between biodiversity conservation and human needs (*1*). Their claim of contradiction, however, is based on a misrepresentation of my analysis and conclusions.

In their analysis, they aggregate mammals, birds, snakes, and amphibians into a single group and compare the total number of species to human population density, whereas I focused specifically on plant diversity in relation to soil fertility and net primary productivity (NPP). I explicitly stated that many vertebrates, particularly large birds and mammals, have a diversity pattern very different from that of plants, and reach their highest diversity in areas with high NPP. This brings their conservation into direct conflict with agriculture, a point I have elaborated elsewhere (*2*).

This conflict is most acute in the developing world, where human population density is strongly correlated with soil fertility and NPP. Infrastructure for food storage and transport has reduced this correlation in most developed countries, where high-production agriculture and urban-based economies have shifted populations out of rural areas. Although the most productive lands will continue to be used intensively, lower human population densities may allow conservation of certain types of species, such as predatory birds, in these agricultural landscapes.

Balmford *et al.*'s analysis does provide a good example of the ubiquitous pattern of maximum diversity at intermediate levels of NPP, which is found in many types of organisms over a range of spatial scales (*2, 3*). However, their use of model estimates rather than measurements of NPP, and the low spatial resolution at which they evaluated diversity, raise questions about the relevance of their analysis to real conservation decisions.

"...more species will be saved if we use our understanding of ecology to minimize the human and economic costs associated with each species that we do save."

The most serious deficiency in Balmford *et al.*'s analysis is the failure to recognize that the diversity of different types of organisms reaches a maximum at different levels of NPP (*2, 3*), with the plant maximum typically at relatively low levels and the diversity of animal predators maximized at high levels. By combining all types of vertebrates, from salamanders and sparrows to eagles and elephants, into a single group, they ignore the fundamental differences among contrasting types of organisms and thus obscure the opportunities for a strategic approach to conservation that could maximize conservation of specific types of organisms while minimizing negative impacts on human welfare and economics.

There is no doubt that conservation will be more difficult and expensive in areas with high human population densities. There will be tradeoffs between human economies and natural ecosystems, and species will continue to become extinct. Nonetheless, more species will be saved if we use our understanding of ecology to minimize the human and economic costs associated with each species that we do save.

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Response

HUSTON RAISES THREE ISSUES CONCERNING our evidence that across Africa, vertebrate species richness covaries with human population density, and that both variables exhibit a similar hump-shaped relation with NPP. First, regarding our modeled estimates of NPP, we used these because field measurements of NPP in Africa are scarce. They are also usually measured over periods that are too short, given the marked interannual variability in Africa's climate, to provide reliable estimates of average NPP levels over time scales that are relevant to biodiversity distribution patterns. Crucially, the modeled NPP values we used compare closely with observations for a range of test sites (*1*).

Second, Huston says that by combining data for all terrestrial vertebrates we "ignore the fundamental differences among contrasting types of organisms." Yet, functioning ecosystems require many functional groups, and hence, as conservationists, we are concerned with all biodiversity, rather than particular subsets of it. That said, in our original analyses we did test explicitly for between-taxon variation, but found little: Each of the four main groups of terrestrial vertebrates exhibited positive correlations across 1° grids between species richness and human density (*2*). Our results also hold when reexamined separately for 10 functional groups ranging from nectarivores to large carnivores: Species richness consistently covaries with the density of human settlement (*3*). As predicted by Huston, the relation between NPP and species richness of functional groups is variable. However, regardless of the exact form of the relation, species richness peaks at intermediate or high (and, critically, never at low) NPP (*3*).

Huston's third criticism is that although these patterns might be true for some heterotrophs, plants are different. However, preliminary analyses suggest that this is not the case. For the 2661 African plant species mapped to date by botanists at the University of York [(*4*); ~7% of the continent's total], the number of species in 1° grids correlates positively with human density (see the figure; Spearman rank correlation $r_s = 0.56$, $N = 1957$ grid cells; compare with $r_s = 0.54$ for terrestrial vertebrates). This continent-wide pattern is also confirmed within Kenya and South