things seem to be moving in the right direction, albeit slowly. For example, the level of funding for research has increased; in 2001, Giuliano Amato's government devoted an additional 450 million euros (US$388 million) to research, using money from an auction of telecommunications licences — although this measure has not been repeated for 2002 by Silvio Berlusconi's government. Italy invests about one-third of the percentage of gross domestic product that Japan spends on research, although resources are starting to be distributed on a more rational basis, involving peer review. However, Palombini points out that simply putting more money into a system that contains too many people who do not share the same values of merit and competition is no guarantee of success.

Most Italian universities are still capable of producing highly talented scientists. Burton Richter, Nobel prizewinner and professor of physics at Stanford University in California, knows the Italian system well, being a member of an international committee charged with reviewing the Italian National Institute for Nuclear Physics. As he writes in this book, he does not understand how Italy can afford the social cost of this continuing brain drain, particularly in the absence of a brain gain from other countries, which is hampered by the bureaucratic and parochial selection system in Italy, as well as by poor funding. I don't understand it either. But reading this book gave me a better idea of the causes and consequences of this process. ■

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The answer lies in the soil

Understanding Soil Change: Soil Sustainability over Millennia, Centuries, and Decades
by Daniel D. Richter Jr & Daniel Markewitz
Cambridge University Press: 2001. 272 pp. £47.50, $69.95

David Schimel

This marvellous little book tells the story of southeastern US ecosystems from the perspective of soil changes over timescales of decades, centuries and millennia. I was delighted with the author's organizing of processes into timescales. This is a natural way of thinking about soil and ecosystem processes, but is more often given lip-service than actually used as an organizing principle. In this case, it works, both because the soil processes — from weathering and geomorphic evolution, through leaching and decomposition — fall into this framework, and because human impacts also change on these timescales.

The first part of the book provides a clear and conceptual overview of the elements of soil science, and their links to human management of soils. The authors demonstrate clearly that sustaining soil "health" is essential to sustaining human societies, and that soil change is linked to historical change in human economy. They then introduce the system that is the focus of their study, the Calhoun Experimental Forest, a property in South Carolina procured during the regional collapse of unsustainable agricultural practices of the southern United States in the first part of the twentieth century.

In the second section, which addresses millennial processes, they review pedogenesis (soil formation) globally and in the old soils of their target region. Here we begin to see the fruit of the sustained research effort at the Calhoun site, as the processes leading to the acid soils of the region are carefully documented in terms of geomorphic, geochemical and biological dynamics. Key findings include the role of biologically generated acidity in attacking the soil's primary minerals.

The third section addresses the centennial timescale. It includes a history of the agricultural development of the South, drawing attention to the little-known intensive maize cultivation system of the indigenous Americans before the arrival of Europeans. The authors provide a detailed analysis of the sustainability of this system, and the human and landscape conditions that allowed its success. They then provide a unique perspective on the 'Old South's' cotton economy in terms of agricultural management and the biogeochemistry of the cotton economy. The discussion on the legacy of cotton growth in today's soils makes fascinating reading, blending political and economic history with soil chemistry. The authors conclude that the previous two centuries of agriculture have affected soils to great depth (two metres) and will continue to affect ecosystems well into the future.

The authors next describe a period over recent past decades during which agricultural land over huge areas in the southeastern United States has reverted from farmland to forest. This is the timescale of the Calhoun experiment and describes in detail the recovery of carbon and nitrogen in soils of the regrowing forest. The rapid and massive response of soil to the re-establishment of forests is astonishing. The Calhoun soils re-establish soil acidity, carbon content and a functioning nitrogen cycle that can effectively retain inputs. Likewise, phosphorus chemistry changes as a result of the increase in organic matter and the associated effects of acidity on the inorganic chemistry of this element. The degree of knowledge of soil processes documented for this site is equalled for only a very small number of other locations.

Down to earth: the Calhoun experiment has studied soil–ecosystem changes over 43 years.

MICHAEL HOFMOCKEL

The final section of the book outlines a research strategy based on a proposed network of long-term soil-research sites and careful experimental design. This proposal, in which the authors argue for a research paradigm based on replicated manipulative experiments, is founded on experience both at the Calhoun site and in other long-term ecosystem studies. While the utility, value and rigour of this approach need no comment, the authors themselves have shown the additional value of a perspective that takes into account the dynamics and legacies of millennial and centennial landscape processes. Decades-long experiments, using conventional manipulation and replicated plots, cannot address the role of slow pedogenic and landscape-scaled processes. For this, the analytical paradigms of the geophysical sciences could be useful, as they can address entities (such as ecosystems) for which replication is a challenging problem, which are difficult to manipulate, and which respond on long timescales. The dependence on fisherian statistics and classical experimental design in soil science is a legacy from agronomy, not altogether suited to large-scale, long-term processes.

This book fills an important niche in the biogeochemical literature, and not only as a regional case study. Forest ecosystems play a large part in global processes, affecting the

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global water, carbon and nutrient cycles. In global studies, processes must necessarily be captured in models, and in general, today's global models greatly simplify soil carbon dynamics, sketch out or ignore nitrogen and totally neglect phosphorus, acidity and cations. This study shows the importance of an integrated appraisal of soil dynamics in ecosystem function, and demonstrates the increasing maturity of soil science. ■

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More from the soil

Tales from the Underground: A Natural History of Subterranean Life
by David W. Wolfe
Perseus, $26, £18.99

Warfare of a chemical kind

War and Nature: Fighting Humans and Insects with Chemicals from World War I to *Silent Spring*
by Edmund Russell
Cambridge University Press: 2001. 336 pp. £35, $55 (hbk), £12.95, $20 (pbk)

Alastair Hay

Metaphors are like pictures; they save text. So, when senior politicians refer to members of the al-Qaeda terrorist network as 'mosquitoes in a swamp', for example, we understand the allusion. An image is conjured up in our minds, and our response may be more visceral than cerebral. The use of metaphors about nature has a long pedigree and may have something to do with our historic contact with the land. Shakespeare, in *Richard II*, has Henry Bolingbroke (a future king) refer to those who wrongly occupy properties of his as: "The caterpillars of the Commonwealth, which I have sworn to weed and pluck away."

Military metaphors have a pedigree too, but their use in agriculture is much more a product of scientific developments in the twentieth century. As Edmund Russell points out in *War and Nature*, over the past 80 years, insects have come increasingly to be seen as the enemy, and suppliers of insecticides have used government and the press to encourage us to buy their products.

This approach was no more evident in the United States than in wartime, and in 1944 the Bureau of Entomology was urging dairy farmers to wage a "War on Insects". At the same time gardeners, if they saw insects, were ordered by the US Department of Agriculture to "shoot to kill". Even magazines for the home, such as *House and Garden*, were on side, insisting on an "all-out attack on fifth columnists in the garden".

By the Second World War, the use of such phrases was commonplace and did not jar with readers. The groundwork had been laid well and had started even before the end of the previous world war. As Russell points out in his book — which largely describes practice in the United States between 1917 and 1963 — towards the end of the First World War, thoughts were on future disarmament, and chemical munitions were high on the list of candidates. Those employed to make chemicals for war could see unemployment looming.

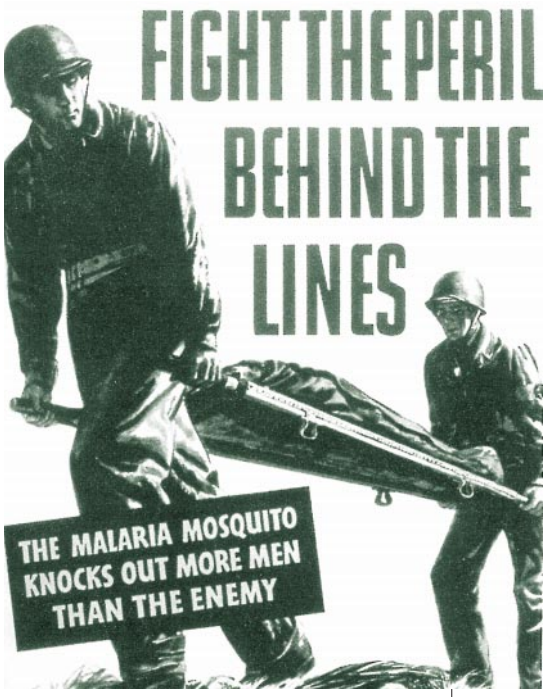
The fight by the US Chemical Warfare Service (CWS) to survive in a postwar era is well known by those who research this area. Arguments used by the agency and some of its leaders that chemical weapons were more humane than conventional munitions have become fokelore. Analysis of the ratio of deaths to acute injuries certainly showed that chemical weapons caused far fewer fatalities than did bullets or explosives. Data on more chronic injuries were rarely referred to.

Proponents of chemical warfare also argued for even more toxic agents to be developed, so that their use could be threatened in future wars as a deterrent to an enemy. Today, it is not just the toxicity of modern chemical munitions, but their potential to cause significant civilian casualties, that is (hopefully) leading to their demise.

But it was not the development of more toxic chemical-warfare agents that helped the CWS to remain intact. The service's survival was due in large measure to some lateral thinking. Armed with the technology to disperse chemicals, all it needed was a new enemy. Step forward the boll-weevil. Long the bane of those who grew cotton, the boll-weevil could at that time only be controlled by the insecticide calcium arsenate. The CWS offered to find a better alternative.

Russell notes that in 1926, after a two-year research programme, alternatives were found, but none was more efficient than the arsenate. Although the outcome was not a success, press reports began increasingly to eulogize the research skills of the CWS. Government appropriations continued to flow to the agency, and collaboration with civilian government agencies and commercial firms followed. Survival of the CWS was assured by this approach and, apart from a later change of name to the Chemical Corps, the *modus operandi* of those involved with chemical warfare in the United States has remained the same.

Russell includes incendiaries as chemical-warfare agents. Germane though they are to his story about the CWS, the inclusion of incendiaries inflates the importance of chemical warfare in the Second World War. Chemical agents today are defined by their toxicity and their mode of action as chemicals that harm life, rather than their flammable properties. The CWS helped to devise



Airborne enemy: the malaria mosquito plagued troops in the Pacific in the Second World War.

and make many of the incendiaries used on Germany and Japan in the Second World War, causing great loss of life. Horrific beyond imagining, these deaths were due to the consequences of the fires and not to direct chemical poisoning.

Russell provides many examples of the interaction between industry and the military and its importance, such as the campaign to spray the insecticide DDT in the Pacific theatre during the Second World War to control the malaria mosquito then besieging US troops. Malaria caused five times as many casualties as military action.

Japanese troops and mosquitoes were juxtaposed in these campaigns, where the emphasis, both in pictures and text, was on elimination of the enemy. This, and other instances of the use of controlling chemicals, provides Russell with ample fodder for a thought-provoking and eminently readable book. A sequel might be about where much of it went wrong. ■

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More on biological warfare

Britain and Biological Warfare: Expert Advice and Science Policy, 1930–65
by Brian Balmer
Palgrave, £45, $75

Chemical and Biological Warfare: A Comprehensive Survey for the Concerned Citizen
by Eric Croddy, with Clarisa Perez-Armendariz & John Hart
Copernicus, $27.50, £17

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