Bacillus thuringiensis were spliced into a maize hybrid, known as Bt corn, to create an organic pesticide against the European corn borer. The Bt corn does not harm beneficial honeybees or ladybugs, but its pollen contains a toxin that kills monarch butterfly caterpillars. Maize pollen can be distributed by wind from cornfields to milkweed plants, the major source of food for monarch caterpillars. In Britain, test fields of genetically altered maize are surrounded by a 200-meter-wide perimeter exclusion zone. Some experts consider this zone inadequate, because modified pollen can move by insects or wind into fields of unmodified crops. Genetically altered plants will continue to face problems in their agriculture and their acceptance by the public.

California prehistory

New pollen data from Mono and Tulare lakes revised eastern California environmental history. Greasewood has not grown in the Central Valley of California in historic times, but the pollen record from Tulare Lake shows that it was common in the San Joaquin Valley 7000 years ago. More surprisingly, giant sequoia were present east of the Sierra Nevada during the late glacial. It was previously thought that giant sequoia disappeared from the Great Basin in the early Pleistocene or late Pliocene (Davis, *Review of Palaeobotany and Palynology*, v. 107, p. 249, 1999; Davis, *Quaternary Research*, v. 52, p. 243, 1999).

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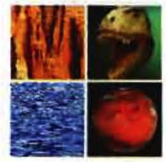

SOILS

Donald L. Sparks

Now is an exciting time to be a soil scientist. We face many challenges and opportunities in the decades ahead. With the world's population estimated to reach 8 to 10 billion by 2050, the wise use of soil and ecosystems will become ever more important in meeting food production needs. (About 99 percent of the world's food and fiber are derived from the land.)

Environmental issues and problems related to soil, air and water quality will certainly continue. For example, global climate change, land degradation, biodiversity, water quality and soil remediation are all research areas calling for collaboration between soil scientists and other physical and biological scientists, as well as engineers, economists and social scientists. These experts are needed not only in research, but also in educating laypersons and policy-makers about important environmental issues.

As it is all aspects of science, technology is revolutionizing the field of soil science. With sophisticated technology and analytical equipment, soil scientists are conducting novel research at multiple scales, ranging from the landscape down to the molecular and atomic scales. The combination of research on these different scales, along with interdisciplinary interactions, is resulting in some major breakthroughs.

Soil scientists are using Geographic Information Systems (GIS) and the Global Positioning System (GPS) to assess land use, urban sprawl and land degradation. Soil chemists and biologists are using synchrotron radiation at national laboratories worldwide to speciate *in situ* contaminants in soils and thus to follow, in real time, the microbial transformations of toxic metals such as chromium and to glean information on metal distribution and speciation in plant roots.

With techniques such as micro-X-ray fluorescence spectroscopy (m-XRF) and micro-X-ray absorption near edge spectroscopy (m-XANES), one can map the distribution of contaminants over micro-millimeter areas and obtain spatial resolutions of less than 5 micro-millimeters.

The interfaces between soil biology, chemistry, physics and mineralogy are major research thrusts.

These studies are providing invaluable information on strategies for contaminant speciation, bioavailability (a nutrient's availability to be degraded or transformed on the microbial level) and enhanced phytoremediation (remediation using green plants). And they assist industries and state and federal agencies in making economically sound judgments on soil remediation.

Soft X-ray microscopy has enabled soil and environmental scientists to definitively understand the macromolecular structure of soil organic matter at different environmental conditions, and to "see" the complexation of metals with humic substances (complexation reactions form complexes, which can prevent precipitation of metals). These techniques, along with advances in computational chemistry and other *in situ* spectroscopic and microscopic techniques (e.g., NMR and SPM respectively), will revolutionize our understanding of soil carbon. Soft X-ray spectro-microscopy will also open new frontiers in understanding the chemistry and mineralogy of many agriculturally and environmentally important low-atomic-number elements such as aluminum, boron, nitrogen, phosphorus, silicon and sulphur.

Biology remains a dominating force in soil science. The interfaces between soil biology, chemistry, physics and mineralogy are major research thrusts.

Examples include: investigations on virus and microbial transport in porous media (such as soils); chemistry and biochemistry of the rhizosphere (soil in immediate vicinity of plant roots); microbial-mineral intetactions; the dynamics of carbon sequestration by soils; water quality and nutrient (such as nitrogen and phosphorus) management issues and policies; and the use of molecular biology to engineer effective biodegraders of toxic chemicals.

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