50 Years Ago

International Tables for X-ray Crystallography. General Editor: Dame Kathleen Lonsdale — The fifty years which have elapsed since the discovery of X-ray diffraction by crystals have witnessed the development of X-ray crystallographic techniques as a structure-determining tool of unprecedented power and catholicity of application. By it the complexities of mineral structures have been rationalized … and the elaborate architecture of the giant globular proteins mapped out. Fortunately, it was recognized early that this diversity would make discipline in the presentation of results, and uniformity of nomenclature and convention particularly desirable. The first attempt to provide such an authoritative basis was by the *Internationale Tabellen zur Bestimmung von Kristallstrukturen* of 1935. In 1946 the International Union of Crystallography decided on a complete revision and extension of these tables under the general editorship of Dame Kathleen Lonsdale. Two volumes … have already appeared; Volume 3, dealing with physical and chemical tables, represents the completion of the 1946 project … No X-ray crystallographical laboratory worthy of the name will fail to add this magnificently printed and luxuriously bound volume to the two they already should possess. **Struther Arnott**

From *Nature* 26 January 1963

100 Years Ago

It is not at all difficult to measure the ionisation produced by the radiation reflected by crystals, as indeed Prof. Barkla has already suggested. Using a sheet of mica and a pencil of a few millimetres diameter, I find it possible to follow with an ionisation chamber the movement of the reflected spot while the mirror is rotated. **W. H. Bragg**

From *Nature* 23 January 1913

compared with fossil-fuel use — even rivalling the benefits associated with growing traditional biofuel crops, such as maize (corn)*.

When assessing the potential climate benefits of biofuels, it is essential to consider the consequences of land-use change and of fertilization associated with growing biofuel crops[3,4] — particularly any changes in the carbon stocks of affected ecosystems, and in the emissions of nitrous oxide, a potent greenhouse gas produced by soil bacteria. It is also crucial to determine whether the growing of biofuel crops poses local threats to biodiversity, or to water and nutrient cycling[5].

Moreover, because biofuel feedstocks are currently produced mostly on fertile agricultural land, it has been questioned whether useful amounts of biofuels can be produced without threatening food production. The ensuing conflict of interest has been called the "food, energy and environment trilemma"[6]. To be acceptable to society, therefore, biofuel-production strategies must be shown to greatly mitigate greenhouse-gas emissions without jeopardizing food and animal-feed production through competition for land use, and to have a minimal effect on the environment.

Gelfand *et al.* compared the biofuel yields, greenhouse-gas emissions, changes in soil-carbon stocks, and energy consumption associated with field operations for six biofuel-cropping systems in the midwestern United States over a 20-year period. They then used these data in a rigorous life-cycle assessment of the climate benefits of the different systems. Because it is based on long-term data, this is the first convincing analysis of the impact of biofuel-production systems on global warming. By contrast, previous studies relied either on modelling or on short-term studies of a smaller number of systems.

The authors show that all the biofuel-cropping systems investigated are net sinks of atmospheric carbon dioxide if fossil-fuel offset credits are included in the analysis. These credits are the sum of all the CO_2 emissions potentially avoided when fossil fuels are replaced with biofuels, taking into account both the production and the combustion of the fossil fuels[7]. Surprisingly, the researchers found that the greenhouse-gas mitigation of wild, perennial, herbaceous vegetation (Fig. 1) — specifically, successional vegetation, which naturally regrows in marginal areas such as abandoned, low-productivity arable land — was markedly higher than that of intentionally grown crops, including maize, alfalfa, poplar and a maize–soya bean–wheat crop rotation, and that energy production was comparable. Moreover, Gelfand *et al.* show that moderate levels of nitrogen fertilization could further boost biofuel yields of the wild vegetation system by about 50%, with only a marginal increase in nitrous oxide emissions.


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Figure 1 | Wild biofuel crops. Gelfand *et al.*[2] report that wild, successional, herbaceous vegetation, such as that pictured, is an effective biofuel crop that has a greenhouse-gas-mitigation capacity rivalling that of traditional biofuel crops.

A big advantage of such native successional systems over other biofuel crops is that they can be productive despite the soil and climate restrictions typically found in marginal lands. This suggests that marginal lands could be a viable alternative to fertile cropland for biofuel production — which would be extremely useful, given the limited land resources[8,9].

To explore the regional implications of their study, Gelfand *et al.* used a computational approach to identify suitable marginal lands for biofuel production across ten states of the US Midwest. More specifically, they used information from a geographical database in a biogeochemical model to estimate the effects of soil and climate on biofuel yields.

One constraint on the production of biofuels is the need to minimize the energy consumed by the collection and transport of the crop. Gelfand and colleagues show that, given the distribution of marginal lands in the US Midwest, optimal biofuel production would be achieved if biomass is collected from within a region of 80-kilometre radius around refineries. Such a production strategy could yield approximately 21 billion litres of ethanol per year from 11 million hectares of marginal land. This is about 25% of the target mandated by the US Department of Energy's Biomass Program for cellulosic biofuel production in 2022 (cellulosic biofuel is that produced from lignocellulose, a major constituent of wood and grasses). It equates to an expected fossil-fuel offset of roughly 40 teragrams of CO_2 equivalents each year (1 teragram is 10^{12} grams) — the same as the CO_2 emissions from 10 million medium-sized cars, each with an annual run of 20,000 km.

So would a native successional biofuel crop be all good? Perhaps not. Gelfand and

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*This article and the paper under discussion[2] were published online on 16 January 2013.