100 YEARS AGO

At the festivities held in Bologna on the occasion of Mr. Marconi's return to his native town, Prof. Augusto Righi, in congratulating his former pupil in his successes, spoke to the following effect:— Perhaps no one can appreciate better than I his exceptional inventive power and his unusual intellectual gifts. I remember with great pleasure his visits when quite a young man, for asking my advice, for explaining his experiments, made with simple apparatus ingeniously put together, and for keeping me informed of his new projects, in which his passion for applied science always stood out. Even then I predicted that he would sooner or later attain fame. The system of wireless telegraphy which he derived from Hertz's classical experiments … is the most pleasing transference to the field of practical industry of those instruments and principles which might have seemed to be relegated to the domain of natural philosophy. ... It is to the credit of Marconi that he has once more proved how much those are in error who regard with disdainful or indifferent eyes the work carried on continuously in the silence of the laboratory by the modest and disinterested scientific students, and who only appreciate science in proportion to the immediate uses that can be obtained from it.
From *Nature* 9 October 1902.

50 YEARS AGO

Philosophic Problems of Nuclear Science. One summer evening in 1925, a small and very select meeting of theoretical physicists took place in one of the Fellows' rooms in Trinity College, Cambridge. It was a special occasion. ... A brilliant young mathematical physicist, fresh from Munich, Göttingen and Copenhagen, was about to expound his work in the field of atomic physics to a handful of people capable of appreciating it. The speaker was ... Werner Heisenberg, before long to become a celebrity for his 'uncertainty principle'. Subsequent events have added not only to his distinction but also to the debt which philosophers and scholars everywhere owe him for the profundity of his thought, and for the elegance of his expression. The present book does something to bring these things home to English-speaking readers. 'Something' is probably fair comment, for here is a collection of lectures, originally in German, translated with obvious sincerity but not always with complete idiomatic success.
From *Nature* 11 October 1952.

the valley's six habitats used for agriculture.

The first-generation model (by Dean *et al.*[3]) had three steps. First, the width of annual tree rings depends on that year's climate, especially rainfall and temperature. Tree rings provide a climate record for Long House Valley extending from the present back to AD 200, with no gaps. To convert tree rings into maize yields, the authors used an empirical relation, observed over the last century, between tree-ring width and a climate measure (the Palmer Drought Severity Index, PDSI)[5] much used by agricultural scientists to calculate crop yields. The modern relation between maize production and PDSI is known for 55 different soils in southwestern Colorado, and one of the 55 closely matches the soil of one of the six Long House Valley agricultural habitats (Long House Valley General Valley floor soil). By converting tree-ring width to PDSI, and then PDSI to maize yield, Dean *et al.* calculated rainfall-dependent maize production, in kilograms per hectare, for that one soil for each year from AD 800 to AD 1350.

The next step involved the reconstruction of past rises and falls of groundwater from flood-plain stratigraphy: rising groundwater is associated with sediment deposition when the flood plain is well vegetated and stable; falling groundwater is associated with instability and erosion, which produces gulleys called arroyos. Soil stratigraphic units, and thus groundwater trends, can be dated to within a few decades by the styles of Anasazi pottery, radiocarbon-dated materials and germination dates of trees buried in each unit. It is known roughly how the combined effect of rainfall and groundwater on maize yields differs among the valley's six habitats. So Dean *et al.* took the time sequence of mean maize yields calculated in step 1 for General Valley floor soil, modified it to estimate the time sequence of yields for the other five habitats, and incorporated random spatial and temporal variations in yields around those mean values.

The last of the three steps in the first-generation model was to construct an 'artificial Anasazi' history by computer. This involved dropping a few virtual Anasazi farmers into the valley at AD 800; feeding them each year with the calculated maize crop; and letting them bear and feed children, grow old, move house sites, and send off grown children to build new houses, according to rules observed for recent maize-growing societies of Pueblo Indians descended from the Anasazi. Examples of these rules are that annual maize consumption per person is 160 kg, that surplus maize can be stored for up to two years, and that children marry and move out at age 16. The iteration was carried out for each year in turn, depending on the calculated maize crop.

The result is one estimation of the valley's total population, and the spatial distribution of its house sites. Dean *et al.* did many such simulations for each year. They turned out to differ in detail (because of the built-in stochastic variation in local maize yields) but were broadly similar. The simulations were then averaged and compared with the actual Anasazi population and its spatial distribution, as deduced from an archaeological survey of house sites (dated by their pottery styles) over the whole of the valley.

The first-generation 'artificial Anasazi' society and the actual Anasazi society compared well in several respects: population rise and fall, population shifts among the six habitats, and alternations between a few large settlements and many scattered houses. But there were two exceptions.

First, the simulated population was about six times the actual population. A likely explanation for this failure lies in previous experience with agent-based modelling, which suggested the model's deterministic demography as the flaw — for instance, that every woman became a mother at precisely age 16, and every household lasted for 30 years. When stochastic variation around those mean values was introduced, the resulting second-generation model[4] accurately reproduced the population size as well as its trajectory with time (Fig. 2). For example, the population peak around AD 1250 was 1,070 people actual, 1,040 simulated. Overall, putting Fig. 2 into words, the population first rose in an initially underused landscape, then remained flat between about AD 900 and 1000 because of groundwater limitation; it rose from 1000 to 1130 and again from 1180 to 1270 because of high groundwater and high or at least constant rainfall; and it crashed from 1130 to 1180, and again after 1275 because of a coincidence of drought with falling groundwater.

The other model failure comes after AD 1275, when the coincidental water shortages induced the actual Anasazi to abandon Long House Valley completely. Where did they go? Many people may have died of starvation. But others moved south to the Hopi pueblos and other climatically less-stressed areas, as shown by population surges and the appearance of Long-House-Valley-like ceramics and sites there. But the model suggests that valley maize yields after AD 1275 could still have fed 400 people, almost half of the peak population earlier in that century. For the first two centuries of their occupation of the valley, the Anasazi were content to live there at a population of under 400. Why did everybody leave the valley after AD 1275, when it seems that half of them could have continued to feed themselves?

When the Anasazi abandoned their settlements, the survivors were evidently motivated by something not considered in the model. One possibility[4] is that complex human societies require a certain population size to maintain institutions that its