

RABBITS AND CLIMATE

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ABSTRACT

Climate change, a phenomenon long familiar to both historians and paleontologists, is now generally accepted. While small changes in atmospheric composition have dominated modern climate change research, less attention has been paid to major changes in meteorological conditions created by large scale clearance of natural vegetation.

The construction of the “Rabbit Fence” to keep rabbits from the eastern States out of S.W. Western Australia early in the 20th century ultimately created a 100,000 km² “laboratory”, not because it succeeded in keeping rabbits out, but because it stopped farming and intense land-clearance activities from spreading eastwards.

Today, contrasting land use practices on either side of the “Rabbit Fence” are clearly visible from space. Local suspicions of rainfall changes are supported by measurements of albedos and atmospheric convection and lifting condensation levels. Regional rainfall changes observed over half a century correlate with land clearance activities.

Detailed observations using specially instrumented aircraft began over 15 years ago and are continuing as more scientists realize that there are many, sometimes surprising, contributing elements to climate change.

THE RABBIT PLAGUE

Rabbits had been introduced to eastern Australia in the mid-19th century where they rapidly multiplied to plague numbers and caused immense damage to both crops and the natural environment.

During the 1890s, rabbits were observed migrating westwards (*see map in fig. 1*) thereby generating concerns in the then colony of Western Australia, which, because of a desert barrier, had hitherto been spared



Figure 1 Map of Australia indicating rabbit migration path.



Figure 2. Drifting sand at Eucla now covers the formerly high walls of the overland telegraph station to the extent that only the chimneys protrude.



Figure 3 The “Rabbit Fence” 100 years after construction.

from the ravages of rabbits.

Following the observation of waves of rabbits passing through Eucla, on the southern coastline near the border of South and Western Australia and where as seen in *fig. 2* substantial erosion was caused by the rabbits eating all of the natural plants, the government of the latter decided to construct

a barrier in the form of a fence commencing at the coastline of the Southern Ocean,

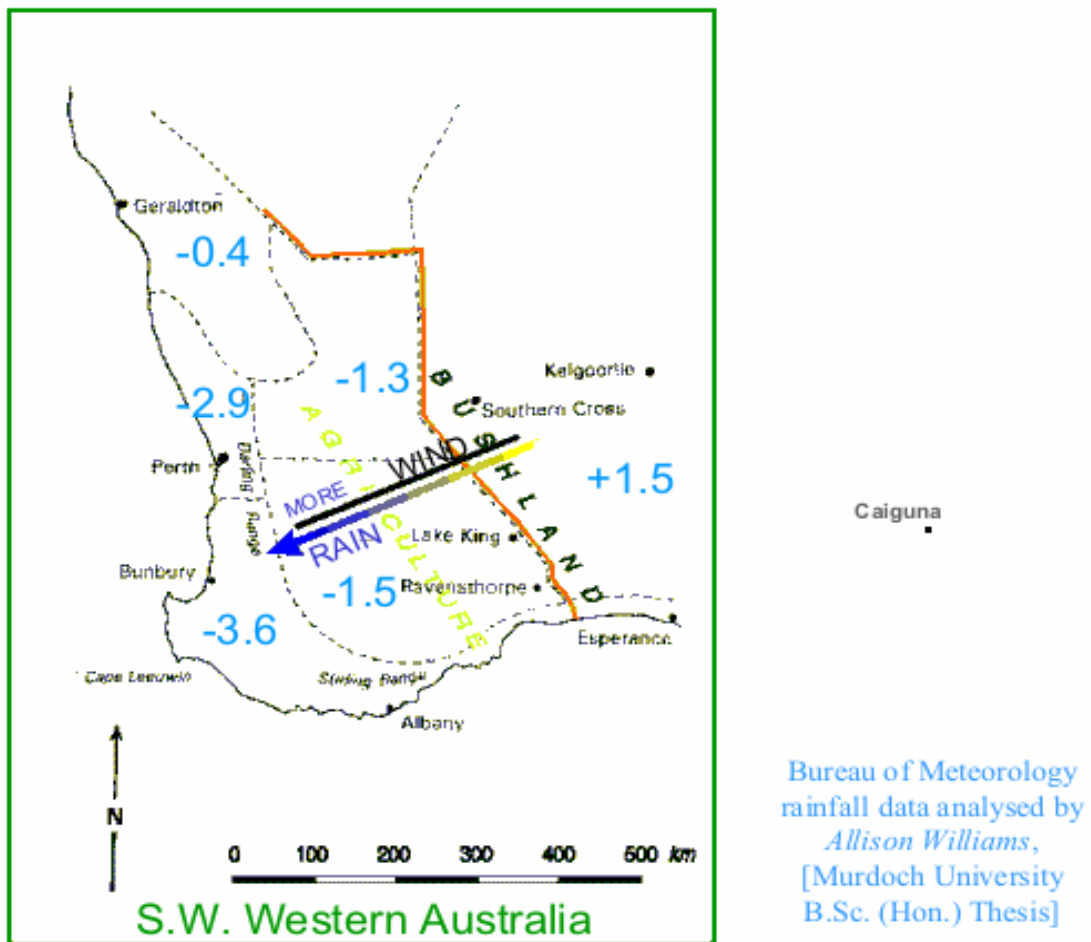
to extend north-eastward to ultimately reach the Indian Ocean, thereby enclosing the important south-western agricultural zone which is shown in greater detail in *fig. 4*.

It is not known for how long the rabbit plague was held up by the fence, which was substantially completed in the first decade of the 20th century, but such were their numbers that it is likely that they formed their own dynamic ramp and leap-frogged over themselves and over the top within hours, or perhaps even minutes of their arrival.

For the State of Western Australia, this was a disastrous failure after the relatively enormous expenditure; but it was mainly because of this cost, that the fence continues to be maintained. Ironically, although it is not impervious to rabbits it does serve a very useful purpose in holding back the eastward advance of further land-clearance for agriculture.

CLEARING LAND FOR AGRICULTURE

Land clearance for agriculture has continued throughout the 20th century in south-west Western Australia, so that the region has become one of Australia's more important "breadbaskets". The scale of clearance accelerated with the "soldier settlement scheme" following the close of World War 2. In this scheme, new farmers, often with little experience were allowed to select land on the condition that the formerly forested land was cleared for cereal agriculture.



Boundaries of Meteorological regions -----
Trend in regional mean annual rainfall 1948-88 (mm/yr)
"Rabbit Fence" boundary —————

Figure 4. Map of S.W. Western Australia, showing the "Rabbit Fence" and climate data.

In her Murdoch University B.Sc. (Hon) thesis, Allison Williams analysed Bureau of Meteorology rainfall records for the years 1946 to 1988 and discovered that for all statistical districts west of the fence, the mean annual rainfall had decreased, while for the single, large district to the east, this quantity had increased. The actual amounts are shown on the map.

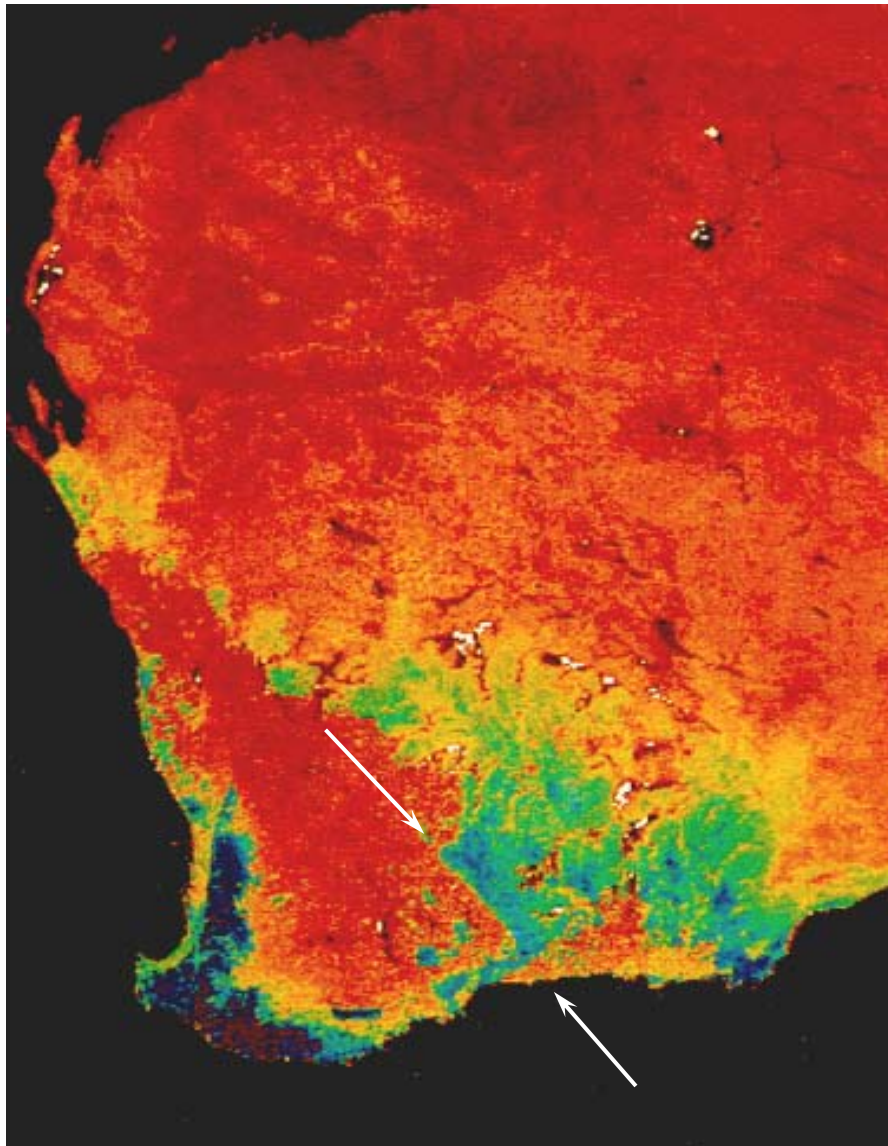


Figure 5. NDVI image of Western Australia, in which the “Rabbit Fence” bounds two contrasting areas. The boundary region studied is indicated by white arrows. The white patches are salt lakes or pans. (Normalized Digital Vegetation Index) image of W.A. in December (early summer, i.e. dry season) with activity of vegetation indicated by colours ranging from red (low) to dark blue (high). At this time of the year, the “Bread Basket” of the S.W. has been harvested and appears as red, because of the absence of living plants and its appearance from space is no different to that of the large central and northern desert areas.

increase in surface salinity, clearly visible from the air as shown in fig. 6. The large number of salt pans are simply highly saline lakes which form when rainfall formerly utilized by living trees, penetrates to link with the subterranean saline aquifer. In summer, these pans may become dry and then appear as a white crystalline crust.



Figure 6. Airborne view of salinised landscape.

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While there may exist some evidence that southwest Australia has experienced a general change in rainfall climate, it is tempting to investigate whether land-clearance could have contributed to this effect. The process of denudation of natural vegetation has been so thorough that it is best shown by NDVI satellite imagery, fig. 5.

Apart from the observed changes in regional rainfall summarized in fig. 4, the other serious consequence has been the

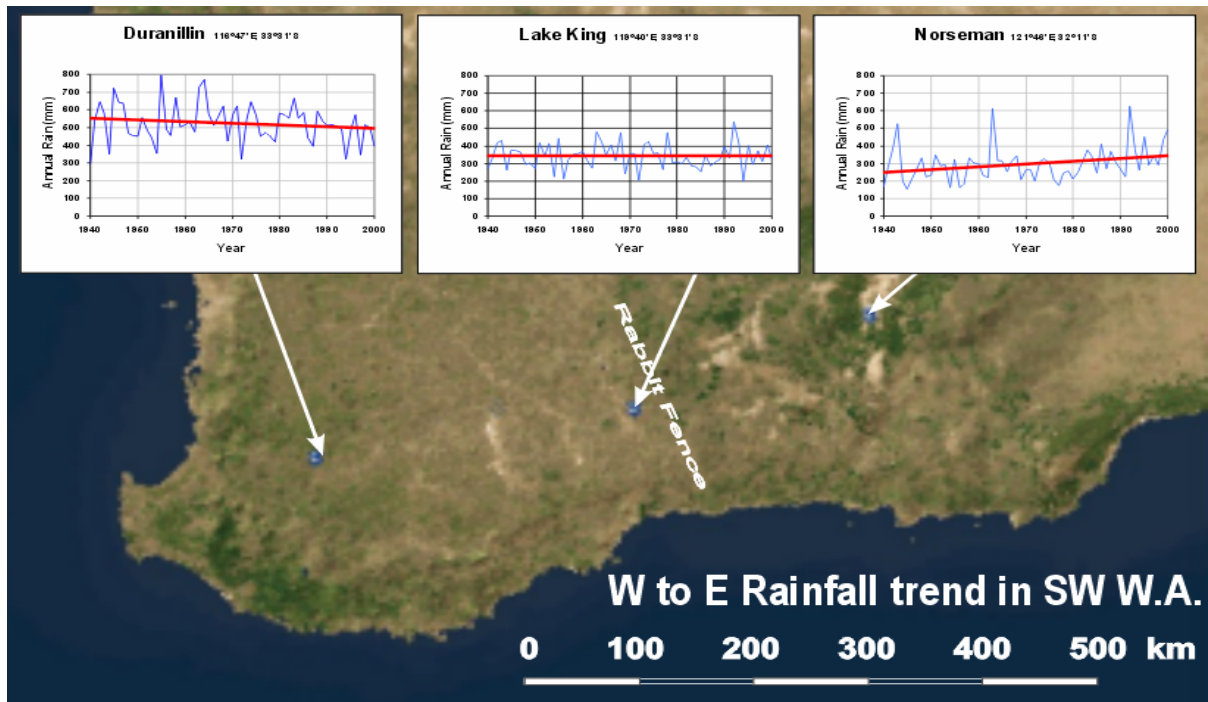


Figure 7. Historic trend in annual rainfall at three stations in S.W. Western Australia, revealing systematic fall at Duranillin, west and upwind of the Rabbit Fence for rain-bearing systems, barely perceptible change at Lake King, close to the Fence and a steady rise at Norseman.

However, the most serious possible consequence of land clearance may well be the steady changes in mean rainfall which have been revealed in *fig. 4*. These are further detailed in *fig. 7* in which the monotonic almost trend in the annual mean rainfall data appears to be closely related to the proximity of the observing station to respectively cleared and uncleared land.



Figure 8. View of cumulus cloud formation while over-flying the Rabbit Fence boundary between woodland (east) and farmland (west).

In jointly conducted observation campaigns (designated RAB1,2,3 etc) by Murdoch and Flinders Universities over several years during the early 1990s, at annual times, representative of all normal climatic seasons, detailed investigations of the atmospheric boundary layer above, as well as the radiative properties of both the cleared (referred to as farm) and undisturbed natural environment (ref. as park) were conducted. Observations of net radiation, incoming and outgoing shortwave radiation, evaporative and convective atmospheric fluxes were made from aircraft as well as at two carefully selected ground-truthing stations. From these, it appeared that significant differences between the boundary layer depths over the two environments could explain the preferred occurrence of convective cloud over the natural woodland areas. The steadily reducing rainfall over the agricultural zone could therefore be at least partially accounted for by the reduction in vegetation density over the 42 year period.

Fig.8 shows a photograph taken from an aircraft at about 3000 m while flying over the Rabbit Fence. The absence of cloud over the cleared, farmed areas, in contrast to the cumulus formed over the natural woodland is striking. It should be noted that the clouds even follow the boundary as it curves toward the west near to the horizon.

It is suggested that the visibly lower albedo of the wooded area, which is quantified by the radiometric measurements summarized in fig. 9 and consequently associated with greater net radiation, could be expected to result in higher convective activity over the tree-covered park.

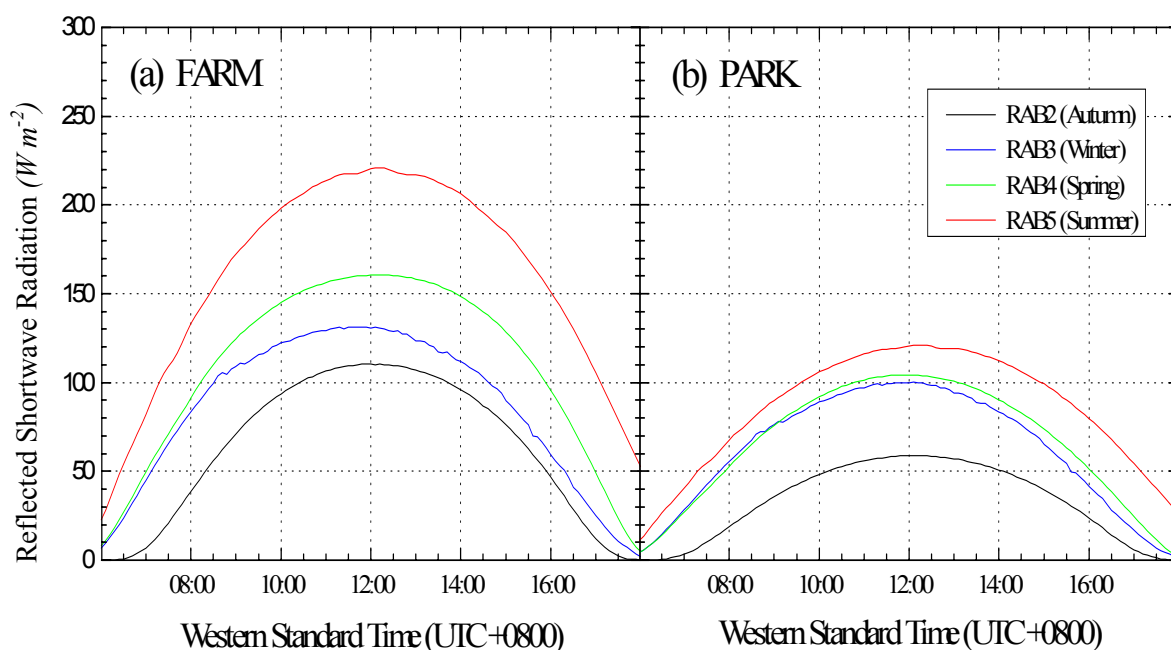


Figure 9. Reflected (and scattered) short wave, or visible, radiation over farm and park.

Using the data from fig. 9, calculated summer albedos have been shown in fig. 10. During that season, the farm albedo is seen to be greater than that of the park by almost a factor of two. During the winter season (June, July and August), cereal crops in the farmed area present almost the same NDVI as the uncleared forest areas, but at this time of the year, atmospheric convection is a lesser phenomenon anyway. It is only after the crops have been harvested in November, that radiometrically, the farmed areas take on the appearance of a substantially un-vegetated desert. The sharp vegetational contrast caused by the differing land-uses west and east of the Rabbit Fence make this, from space, Australia's most visible man-made phenomenon.

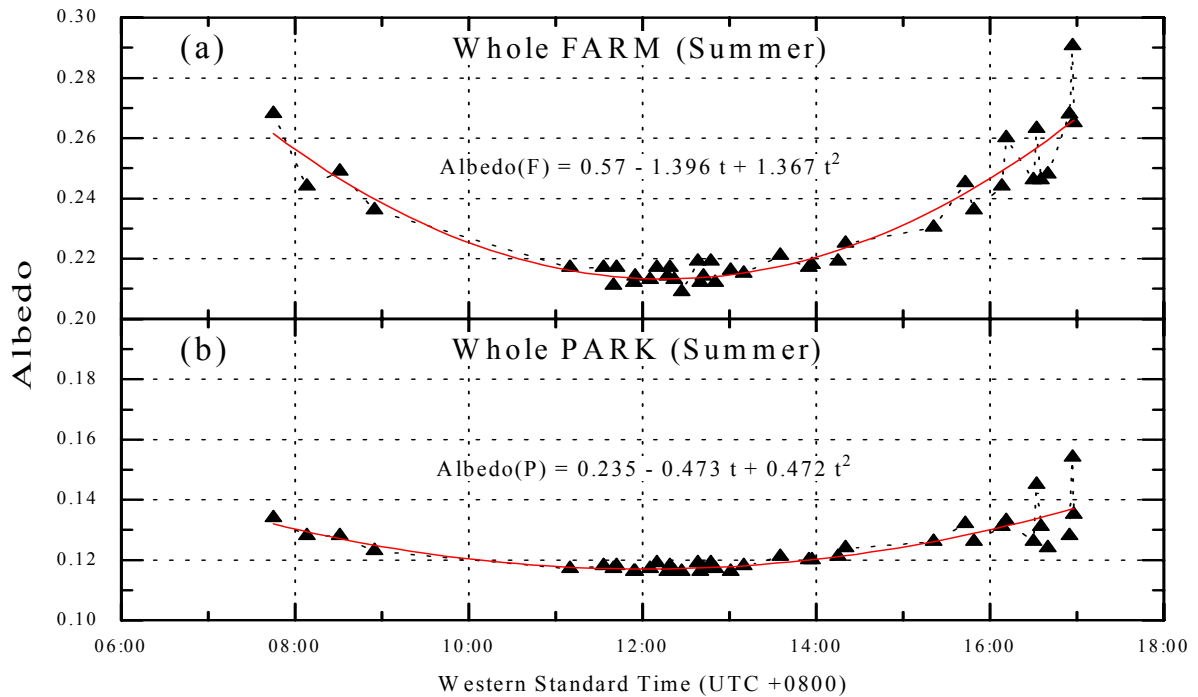


Figure 10. Diurnal record of albedos of farm and park surfaces during summer. (From S. Chambers, Ph.D. Thesis, 1998)

Two specially instrumented aircraft, the slower one with a net radiometer and both equipped with rapid response turbulence, temperature and humidity sensors, as well as short wave radiometers, were flown in systematic horizontal and vertical flight patterns on several occasions, in all seasons to determine the convective activity in the atmospheric boundary layer. Using the turbulence data from these flights, the average boundary layer depth was determined for the cleared, farmed and the uncleared natural woodland environments respectively. The results are shown in *fig. 11*.

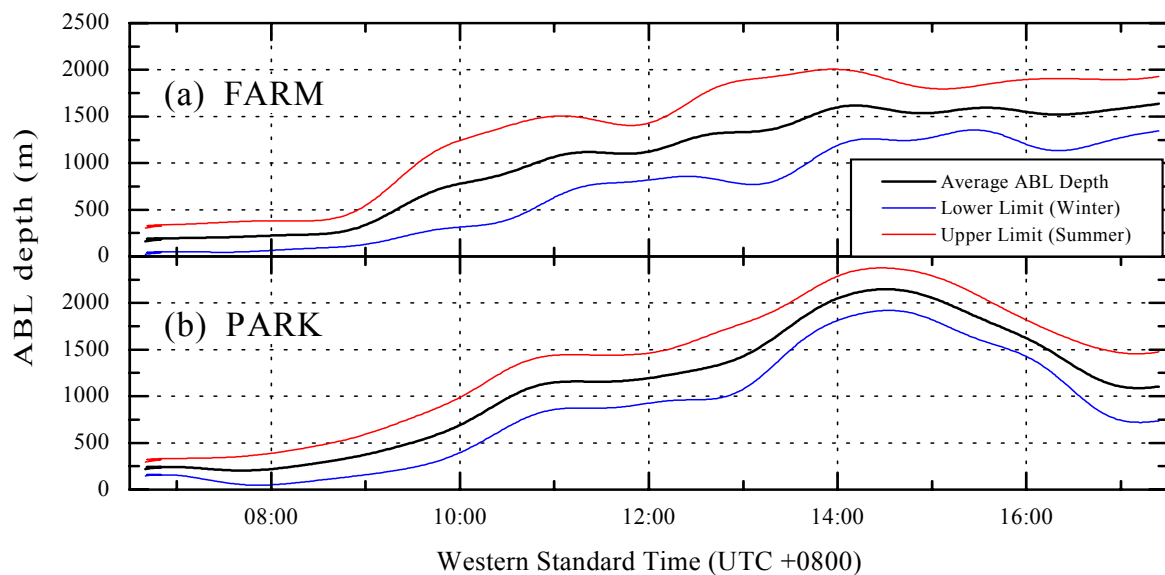


Figure 11. Mean depths of the Atmospheric Boundary Layer over farmland and park, showing the average value as well as the extremes in summer and winter. (From S. Chambers Ph.D. Thesis, 1998)

The remarkable differences in boundary layer depths in summer, and surprisingly also in winter clearly seen in *fig. 11* offer substantial strength to the argument that large scale land clearance can have significant climatic consequences, since higher levels of buoyancy bring air into cooler environments where condensation of moisture is more likely to occur.

Ironically, rabbits, normally regarded as destroyers of land and vegetation in Australia, caused a government to build the fence which ultimately broke the rapid pattern of expansion of mankind's agricultural activity. Although the barrier of the Rabbit Fence is only symbolic and it could be broken through at any time, at least a little time has been offered for a lesson to be learned.

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