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Report for 1964

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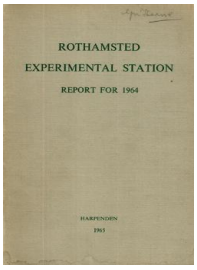

Broadbalk Wilderness

Garner, H. V. , Witts, K. J. , King, D. W. , Jenkinson, D. S. , Yuen, P. H. And Skinner, F. A.

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poorly and because the sugar beet suffered from drought in the later part of the growing season.

Broadbalk Wilderness

History (*H. V. Garner*). J. B. Lawes told the 39th wheat crop occupying the top end of Broadbalk just before the harvest of 1882—"I am going to withdraw all protection from you, and you must for the future make your own seedbed and defend yourself in the best way you can against the natives, who will do everything in their power to exterminate you" (Lawes, 1884 b).

The half acre of standing corn thus abandoned to fight it out with the weeds turned into the Wilderness that has provided a fascinating side-show for thousands of visitors to the fertiliser plots. The sequence of events on this area and the observations arising from them have been written up from time to time, but not recently; since the last account an additional treatment has been introduced. The early effects of this grazing treatment are recorded here, with an historical note on the Wilderness and a brief summary of some of the scientific investigations based on it.

On a map of the Rothamsted Estate dated 1623 the Lower Shepcote Fielde of 16·3 acres is shown with the same boundaries as the present Broadbalk. The centre of this piece, amounting to about 12 acres, was under arable cultivation; the remainder was accounted for by broad grass verges, of which the lower one at the western end of the field was the largest. The oldest surviving plan of the wheat experiment was made in 1851, after the plots had been in existence for 8 years. The total area of the plots was then 11·2 acres. This comprised 9·2 acres of full-length manurial plots almost coincident with the present ones, some shorter ones at the side of the field, later abandoned, and two transverse half-acre strips: the Upper Butts at the top of the field and the Lower Butts at the bottom. These butts were always unmanured, and their yields, which were measured from 1851 to 1872, supplemented that of the better-known control plot which ran the full length of the field. It is on these butts that the history of the Wilderness begins.

In the Broadbalk *White Book* there is an entry for 1882 that says "Top and Bottom Butts. No wheat grown on this portion of the field after the harvest of 1882." The writer of this note did not mention that the wheat standing on these areas was not harvested, and the record says nothing more about them for the next 20 years. Our information comes from Sir John Lawes himself: in March 1884 and again in September of the same year he wrote articles for *The Country Gentleman* describing the fate of the abandoned crop (Lawes, 1884). It shed its seed, estimated at about 13 bushels/acre, in an exceptionally wet autumn and weeds grew strongly during the following mild winter. The crop came up, but was almost completely suppressed by a dense mass of couch grass (*Agropyron repens*). So little survived at the harvest of 1883 that Lawes estimated the produce of the top half acre at only a few pints. He decided to leave this crop to shed its seed once more, although its chance of growth was small. Nothing more is heard of this experiment for 11 years till Lawes (1895) came back

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to the subject in *The Agricultural Students' Gazette* in 1895. This is a much fuller account. There is a photograph of typical ears from samples taken at harvest time from the first, second and third self-sown crops in 1883, 1884 and 1885 respectively. In the first year the ears were normal, though the stand was very thin, but in the subsequent years the plants were barely recognisable as cultivated wheat, with only two or three grains in the ears. The wheat died out after the harvest of 1886, when two or three diminutive plants were found. They are still preserved in the Conference Room. Lawes makes it clear that there was an abandoned area at the bottom as well as the top of the field, for he repeatedly refers to the "top and bottom" of the field and states that in 1882 some parts must have shed seed at over 30 bushels/acre. This could only have come from well-manured land, and the 1852 sketch plan of Broadbalk shows that the bottom butts embraced the ends of some of the fully manured strips. This paper, written 13 years after enclosure, mentions the invasion of the top portion by young oak and ash trees, and hazel, rose and hawthorn bushes, starting near the hedge. Soon after this the trees must have been removed from half the area to allow the ground vegetation to develop, leaving the remainder to revert to natural woodland. Except for the regular grubbing of bushes in the "meadow" half, nothing further was done in this wilderness for about 60 years.

The history of the bottom portion is sketchy, and it is clear that interest in this piece was soon lost. In 1895 it was included in a botanical survey made by J. J. Willis, for he mentioned differences in the prevalence of some species between the top and bottom of the field. In 1896 the present brick drainage trench was dug out, and the earth thrown out formed a ridge on the bottom piece, which was soon colonised by rabbits. The area soon became very rough, though not wooded, and so remained till it was reclaimed for allotments at the beginning of the First World War. After a few years in experimental flax it passed into ordinary arable cultivation.

In 1957 the Field Plots Committee decided that one-half of the meadow section should be fenced off and grazed by sheep, to study the long-period changes in the herbage induced by stocking. A botanical survey showed that the weed vegetation contained some poisonous plants, so for the first 3 years the herbage was cut with a motor scythe several times during the growing season and allowed to lie on the plot. Then in March 1960 sheep-grazing began and has since continued. The animals are put on whenever there is enough herbage for them to eat, which happens about 6 times during the growing season. Five sheep are usually needed for a 7-day period, after which the plot is topped and left to grow again. On the average of the last 5 years the plot has provided grazing at the rate of about 1,020 sheep days per acre. This is 58% of the grazing provided by the Rothamsted leys and reseeded grass and 65% of that of the Woburn leys in the Ley–Arable experiments over the same period.

Flora (*K. J. Witts*). The first weed survey was made by J. J. Willis in 1886 and showed a total of 40 species of herbs, with common bent-grass (*Agrostis tenuis*) and black medick (*Medicago lupulina*) as co-dominants. Willis surveyed the Wilderness again in 1894, when he identified 49 species

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of herbs with the same two dominants but also with abundant meadow vetchling (*Lathyrus pratensis*). A survey in 1903 by an unknown recorder (probably Willis, for he was still at Rothamsted) showed 57 species present, with dominance shared by cocksfoot (*Dactylis glomerata*) and meadow vetchling.

Initially the vegetation of the Wilderness was composed of herbs, but after a time tree seedlings appeared and began to dominate the lower-growing vegetation. To prevent the Wilderness from developing into a wood it was halved, one half was left undisturbed, whereas from the other all tree seedlings were removed each winter. In 1913 Brenchley and Adam (1915) surveyed the "grubbed" half of the Wilderness on several occasions. They probably recorded the species more completely than any of the earlier recorders, and they listed a total of 65 species, with oat-grass (*Arrhenatherum elatius*) and lesser knapweed (*Centaurea nigra*) as co-dominants. Twenty-three of the species recorded in 1913 had been present in 1886, but 42 had come in since and 17 had been eliminated, presumably by competition.

Between 1882 and 1913 the composition of the Wilderness flora changed greatly as the original weed species, which had had the initial advantage of already being there, were replaced by other species not usually associated with cereal crops but able to enter the community and to compete successfully with the established species in uncultivated ground.

A feature of the grubbed half of the Wilderness in 1913 were two large patches of ivy (*Hedera helix*), which were apparently spreading and eliminating all other species. The conclusion was then reached that the whole of the grubbed half of the Wilderness would become covered with ivy, but this proved unjustified, and ivy has now almost disappeared from this half, although it forms a dense carpet beneath the trees in the ungrubbed half.

In 1951 the grubbed half of the Wilderness was surveyed by D. L. Curtis, who identified 35 species of herbs and 11 woody species. He considered his list incomplete, because he recorded the vegetation only in late August. He noted that parts of the Wilderness near the trees and by the adjoining buildings was dominated by hogweed (*Heracleum sphondylium*), possibly because the areas were sheltered from the south-west winds. Other parts were dominated by creeping fescue (*Festuca rubra*) or oat-grass and lesser knapweed.

In 1956, when it was decided to test the effect of grazing on part of the grubbed half of the Wilderness, the vegetation was surveyed on six occasions between April and December. The vegetation was not only surveyed visually, but to make the record more accurate and to show changes produced by grazing, 17 permanent quadrats, 4 links square (0·65 m^2) were laid down at regular intervals and the percentage cover of each species measured. Forty-nine species of herbs and 10 woody species were identified. In the spring, parts of the Wilderness were dominated by dog's mercury (*Mercurialis perennis*), which was succeeded by cow parsley (*Anthriscus sylvestris*) and in late summer by hogweed. In the southern part of the grubbed half of the Wilderness, away from the trees and adjoining buildings, the vegetation was composed principally of creeping fescue and other grasses throughout the year.

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The surveys of 1956 showed several species harmful to stock, and in an attempt to eliminate these, the vegetation was mown. Mowing was done at intervals throughout the summer of 1957, and the quadrats were recorded again in December of that year. The initial effect of mowing was contrary to expectations, for there was an increase in broad-leaved species, principally ground ivy (*Glechoma hederacea*), a species suspected of being poisonous to livestock. The quadrats were surveyed again in spring 1959 and after another season's mowing, when the cover of broad-leaved species had declined and grasses, especially meadow-grass (*Poa trivialis*), had increased. The cover of tall-growing species such as hogweed, cow parsley, dog's mercury and lesser knapweed was much diminished by mowing, although there were still many seedlings.

Five of the quadrats nearest the Wilderness boundaries were atypical, so they were abandoned and attention concentrated on the remaining twelve, six on the unmown and six on the sown sections. These twelve quadrats have been recorded in spring of each year.

Because the plants suspected of being poisonous to stock had diminished, sheep were introduced into the mown section in 1960. The grazing has increased the grasses, particularly meadow-grass, and decreased the broad-leaved species, although the differences in cover of broad-leaved species in early spring is not very different on the grazed and ungrazed sections; the difference in the two sections becomes greater after the first grazing in spring, when the sheep remove the top layer of broad-leaved vegetation. Grazing has altered the nature of the vegetation so that, whereas the ungrazed section has remained an open community with some bare ground, the grazed section has the appearance of a thick turf, with the broad-leaved species tending to push through the mat of grasses. During summer the vegetation in the ungrazed section reaches a height of 3–4 ft, while the grazed section retains the appearance of a grass sward.

Grazing and mowing have both shortened the vegetation and so encouraged the growth of grasses. Grazing, however, has had two other important effects. The urine and droppings of the sheep have increased the fertility of the plot, and the grazing animals have introduced new species. The first new species was seen in 1962, when ten clumps of perennial ryegrass (*Lolium perenne*) appeared in the grazed section. In 1963 there were more than 50 such clumps, but there was no further increase in 1964. White clover (*Trifolium repens*) also appeared in the grazed section in 1962. This species can increase vegetatively by stolons, and from a patch 3 ft in diameter it increased by 1964 to a patch 11 ft in diameter. In 1963 there were also 10 small scattered patches of white clover, and in 1964 more than 50. Other species of plants to appear in the grazed section in 1963 were spear thistle (*Cirsium vulgare*), black medick and patches of smooth hawk's-beard (*Crepis capillaris*). By 1964 all these species were more numerous, and there was a single red clover (*Trifolium pratense*) plant in one of the quadrats. As well as the increase in the number of species in the grazed section, the growth of dandelions (*Taraxacum officinale*) has also increased, although the sheep eat the crowns of these plants in preference to other species.

The vegetation of the ungrazed section has remained unchanged during

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the years 1956–64 and is apparently stable, whereas in the grazed section the number and distribution of species is changing greatly and the composition of its vegetation is unlikely to become stabilised for some years.

The ungrubbed half of the Wilderness was described by Brenchley and Adam in 1915 as a dense thicket of trees and shrubs composed of common oak (*Quercus robur*), hazel (*Corylus avellana*) and blackberry (*Rubus* sp.), with a carpet of ivy. The Wilderness trees were surveyed again in 1945 by Thurston, who counted and identified the trees and measured the diameter of their trunks at a height of 3 ft from the ground. In order of abundance they were hawthorn (*Craetagus monogyna*), ash (*Fraxinus excelsior*), common oak, maple (*Acer campestre*), holly (*Ilex aquifolium*), sycamore (*Acer pseudoplatanus*), cherry (*Prunus* sp.), hazel, blackthorn (*Prunus spinosa*) and elder (*Sambucus nigra*). There were also about 40 sycamore saplings. In 1960, when Witts made a survey, the sycamore saplings had grown considerably. There were many more hawthorns, and at the southern end of the Wilderness some elderberries. Many hawthorns and hazels were dying, probably because they were shaded by the taller trees, which had grown considerably in girth since 1945 and were about 60 ft tall. The ground cover of ivy noted in 1913 still persisted, but the blackberries had disappeared.

In December 1959 six trees on the edge of the Wilderness were felled because they were shading the wheat plots. Counts of their annual rings showed that the central ring dated from about 1908. Thus, in its first 36 years the Wilderness was composed principally of herbs, and trees became dominant only after this period.

Soil Investigations

Classification (*D. W. King*, *Soil Survey of England and Wales*). In 1953 two pits were dug in the Wilderness, one in the grubbed section and one in the wooded section, and the soils described under the code numbers Ht 38 (grubbed) and Ht 37 (wooded). The soils, which were grouped with the Batcombe series, have about 12 in. of loam overlying clay, which shows some mottling. Both sites are calcareous, with the most calcium carbonate (5%) in the 6–10-in. layer. This chalk is probably the residue of that added in the eighteenth and early nineteenth centuries. The main difference is that the soil of the grubbed section shows a clear boundary at 6 in. between the dark-grey top layer and the underlying brown layer, but the wooded section does not. The top 3–4 in. of the grubbed site is almost free from stones.

The accumulation of organic matter (*D. S. Jenkinson*). Lawes (1895) forecast that the Wilderness soil would accumulate nitrogen, a forecast confirmed by Hall (1905), who sampled the Wilderness in 1904. Hall (1905) estimated that the top 27 in. of soil had gained almost exactly a ton of nitrogen per acre by 1904. The organic carbon content of the soil also increased, but proportionately less than the nitrogen, and the C/N ratio of the top 9 in. fell from 10·6 in 1881 to 8·5 in 1904.

Soil samples were taken from both grubbed and wooded sections of the Wilderness in 1964 (Jenkinson and Bloomfield, see p. 80) by Lawes and

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Gilbert's original method so that they were comparable with those taken in 1881 from the adjacent plots in Broadbalk and in 1904 from the Wilderness itself. In 1964 the wooded and grubbed sections contained almost the same amount of nitrogen in the top 27 in., despite the great differences in vegetation between the two sites. When corrections are made for changes in the bulk density of the soil the top 27 in. has gained an estimated 1·75 tons nitrogen/acre since Lawes allowed the top part of Broadbalk to revert to wilderness.

Nematodes (*P. H. Yuen*). Of the 81 species of nematodes extracted in 1964 from the soil of the ungrazed grass and woodland, 53 occur in both. In the ungrazed part the distribution of seven species of spiral nematode, *Helicotylenchus* spp. and *Rotylenchus* spp., is influenced indirectly by trees situated around the boundaries (Yuen, 1964). *H. vulgaris* and *R. pumilus* in the ungrazed part are most abundant in late winter/early spring and in late summer/early autumn. In the woodland and ungrazed grassland nematodes are most abundant in the upper layers, whereas in the wheat on Broadbalk only few live in the 0–2-cm layer and most at between 6 and 8 cm. *H. vulgaris* and *R. pumilus* occur predominantly at different depths in the ungrazed area, and their distribution seems not to be related to moisture or root content of soil.

Soil microbiological investigations (*F. A. Skinner*). Between October and December 1960 Professor K. Kuzniar of Pulawy, Poland, compared the cellulose-decomposing abilities of some Rothamsted soils, and measured the decomposition of filter-papers buried at different depths down to 50 cm in pits dug in the woodland and grazed grassland areas of the Wilderness. In the middle of February 1961 the filter-papers were removed and the loss of cellulose determined. In the woodland soil appreciable decomposition of cellulose (up to 62% loss) occurred only in the top 10 cm, and at 40–50 cm did not exceed 7%. In the grazed area decomposition was much greater; nearly 89% was decomposed in the top 10 cm and 56% even at 40–50 cm depth. There were similar differences in the decomposition of linen strips buried down to 50 cm in these soils.

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