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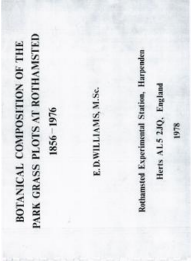
Botanical Composition of the Park Grass Plots at Rothamsted 1856-1976


BOTANICAL COMPOSITION OF THE
PARK GRASS PLOTS AT ROTHAMSTED
1856 1976

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Histrory of the Work on Botanical Composition of the Plots and the Need for Further Analysis

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sample strips by forage harvester and the dry matter content of sub-samples taken immediately after cutting. Thus, dry matter yields since 1960 cannot be directly compared with those before 1960. The remainder of the herbage on each plot is then made into hay. During fifteen of the first twenty years of the experiment the aftermath was grazed by sheep. Since 1887 all of the second cut has been carted, weighed and yield given as hay, or since 1960, as herbage dry matter. In addition to work on the botanical composition of the plots, chemical analyses of soil and herbage have also been made at intervals (e.g. Lawes & Gilbert, 1900; Warren & Johnston, 1964) and recently the soil and surface fauna have been surveyed (Edwards & Lofty, 1975; Edwards, Butler & Lofty, 1976).

The full Latin names of species whose generic names only are given in the text appear in Table 4. These are as in Clapham, Tutin & Warburg (1962). Also in Table 4 are the common names recommended by the Botanical Society of the British Isles (Dony, Perring & Rob, 1974).

HISTORY OF WORK ON BOTANICAL COMPOSITION OF THE PLOTS AND THE NEED FOR FURTHER ANALYSES

The experiment soon showed how yield could be increased by fertilisers. For example, even in 1856 yield was trebled by P and K and the largest amount of N. Differences in yield have persisted and become accentuated since although yields declined on most plots they did so more on some than on others.

The treatments also soon began to change the botanical composition of the swards. In their report of results during 1856-58 Lawes & Gilbert (1859) wrote: "Perhaps the most remarkable and interesting of the effects of the different descriptions of manure upon the complex herbage of which the experimental meadow was composed was the very varying degree in which they respectively developed the different kinds of plants. In fact, the plots had each so distinctive a character in regard to the prevalence of different plants that the experimental ground looked almost as much as if it were devoted to trials with different seeds as with different manures. So striking and characteristic indeed were the effects produced in this respect that in 1857 and 1858 the subject was considered to be of sufficient interest to induce us to request the examination of the plots by Professor Henfrey, to which he kindly assented".

Lawes & Gilbert noted that the 'character of the herbage' was fairly uniform throughout the field at the start of the experiment but that unfortunately little evidence was obtained on the changes that occurred during the first seven years (Lawes, Gilbert & Masters, 1882). There is, however, some information for the early years. During the second year (1857) samples of herbage were taken for botanical analyses from many of the plots but the results were not published. In 1858 samples of herbage were taken from seven plots, sub-sampled and using specimen plants to aid identification a number of boys were set to pick from the weighed sample all they could find to correspond with the types. This left a large 'undetermined residue of detached foliage and undeveloped stems' which was then separated into four or five different lots. The separations were supervised by Dr. E. Pugh of Pennsylvania. The percentage contribution to the air dry (or hay) weight of the different fractions were then calculated (Lawes & Gilbert, 1859). About 20 species of plants were identified in these analyses; the main grasses were *Lolium* and *Holcus*. Further details are given when the botanical composition of individual plots is discussed. In 1862 a complete botanical analysis was made of all plots and this was repeated at five-year intervals until 1877. By this time the

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method of analysis had improved. Small samples of plant material were taken from each swath and, after careful mixing of the total sample, a sub-sample was laid out to dry. Small handfuls were placed in front of each person and separated, as far as possible, into species; the separations were revised by a superintendent (W. Sutherland in 1862, R.L. Keenan in 1867, W.B. Hemsley in 1872 and W. Davis in 1877) assisted by J.J. Willis on each occasion. Part of the undetermined residue was sorted by the superintendent and the remainder "separated into portions of different character by sieves which facilitated identification of the remaining components. These later stages were, nevertheless, very tedious and laborious". The 1862-77 analyses were thus more exhaustive, and became increasingly so, than the 1858 analyses: this is reflected by the much larger number of species (c. 50) identified in these later analyses and by the smaller proportion of unsorted remainder. Some plots were analysed in this way in 1903, when the four-year liming scheme was introduced, and all plots were analysed in 1914 and in 1919 and during 1948-49. These were supervised by Dr. W.E. Brenchley, Miss Grace Bassil (Mrs. R.G. Warren) and Miss Heather Pellant respectively. The method of sampling in these years was similar to that described previously and is given in detail by Brenchley & Warington (1958). Many plots were also completely analysed in many years between 1920 and 1946, with some plots being analysed every year between 1921 and 1935. No analyses were done between 1949 and 1973; during 1973-76 selected plots, or sub-plots have again been analysed. In addition to the complete botanical analyses described, partial analyses have also frequently been done on samples from the plots, when only the three main groups of plants – grasses, legumes and 'other species' were separated. Except during 1895-1902, either complete or partial analyses were done in all years between 1874 and 1948 for plots 3 (unmanured), 7 (PKNaMg) and 9 (N_2PKNaMg).

Visual surveys of the plots also have been made throughout the course of the experiment. Until 1920 the copious notes frequently made of the vegetation were recorded in the 'White Books'. These are hand-written detailed records of all agricultural operations and observations made on the plots. Since 1920 visual surveys of the herbage have been made twice a year, before the hay is cut in June and in autumn, before the aftermath is cut. At survey, all species in inflorescence on a plot are noted and ascribed a score, on a five-point scale, for abundance. A record is also made of the species which are obvious in the vegetative state. This method of recording grassland is relatively quick and is useful to describe the larger differences between plots and major changes with time for some species. However, comparisons of the data for hay analyses in 1947, 1948 and 1949 with the corresponding visual surveys which preceded them show that the abundance score ascribed to a particular species is a poor indicator of the *amount* (or contribution to hay weight) of that species (Table 5) since there is a very poor correlation between the two. Visual surveys also, on average, detect many fewer species on the plots than do botanical analyses of hay samples (Table 6). Furthermore, species like *Agrostis* which may be abundant on some plots but do not flower until after the June survey are inevitably underestimated. Another difficulty is that small differences in time of survey may greatly affect the apparent relative abundance on plots dominated by two species which differ in time of heading, e.g. *Anthoxanthum* and *Holcus*, and *Alopecurus* and *Arrhenatherum*. Many plots are now dominated by one of these two pairs of species.

Botanical analyses of samples of hay from the Park Grass plots were discontinued after 1949 for several reasons. These included the fact that the plots appeared at that

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time to have reached a relatively stable state, doubts about the relevance of the experiment to the practical problems of modern agriculture as well as the laborious nature of the work and the development and expansion of other interests within the Botany department. The experiment did, of course, continue to be of interest to a wide range of disciplines but the emphasis had shifted from the original agricultural aspects to more ecological ones.

During recent years there has been a resurgence of interest in the Park Grass plots over and above their continuing value as a demonstration of how botanical composition may be changed by fertilisers. The liming scheme introduced in 1965 (Warren, Johnston & Cooke, 1965) has added a new dimension to the experiment. Apart from plots 13, 18, 19 and 20, this was the first change of treatment since the original liming scheme was begun more than sixty years previously. As a result of recent lime, changes have occurred in the botanical composition of many sub-plots; hay analyses were therefore resumed to assess these changes in greater detail than could be done by visual survey (Williams, 1974). During these analyses it became clear that changes had also occurred on plots with unchanged treatment and it became desirable to extend the work to analyse some of those plots not yet in the new liming scheme. In the absence of any recent published data on the botanical composition of the Park Grass plots it is occasionally assumed by those not seeing the plots that this has not changed since the last analyses in 1949; less frequently the large difference in the present day composition of some plots compared to the 1948-49 data has been interpreted by those seeing the plots as a measure of the inaccuracy of those data. In recent years the realisation that old permanent pastures may often yield as much as sown leys and that bred varieties are not necessarily superior to locally-adapted indigenous species under all conditions has resulted in renewed interest and a reappraisal of the agricultural value and ecological requirements of 'native' species (e.g. Elliott, Oswald, Allen & Haggar, 1974; Haggar, 1976). There has also been increased interest in amenity grasslands and the maintenance of floristic diversity (Way, 1969; Duffey, Morris, Sheail, Ward, Wells & Wells, 1974; Lowday & Wells, 1977). The Park Grass plots provide information relevant to both interests.

Ideally, a thorough appraisal of the vegetation of all the plots would involve analysis of large duplicate or triplicate samples from all sub-plots for about three successive seasons. With the traditional method of hay analysis such a programme could occupy about ten people trained in hay analysis about three years. This was clearly not possible. The approach adopted during the current programme of work was, therefore, to ask specific questions at the outset.

(1) In 1973 analyses were done to assess the effects on botanical composition of applying lime between 1965 and 1968 to previously unlimed sub-plots *c* by comparing their composition with permanently unlimed sub-plots *d*.

(2) In 1974 analyses were done to quantify any changes brought about by giving increased rates of lime to previously limed sub-plots *b* by comparing them with sub-plots *a* (at that time being limed under the old scheme). Additionally, analysis of sub-plots *a* was intended to provide a base for the study of any future changes on these sub-plots when they were brought into the new scheme to raise their pH to 7. This phase was started in January 1976 but its effects are not investigated here.

(3) In 1975 analyses were made of those plots not yet in the new liming scheme, i.e. with unchanged treatment, to assess what changes had occurred since the previous analyses in 1948 and 1949. Additionally, comparisons of sub-plots *d* in 1973 and *a* in 1974 with the unlimed and limed halves respectively of the same plots in 1948-49 also

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give a measure of change during quarter of a century on the parts of the ammonium sulphate plots which had received unchanged treatment.

(4) To obtain a measure of seasonal variation the unlimed and limed half-plots of three of the plots sampled in 1975 were again sampled in 1976 together with two sub-plots sampled in 1974 and one sampled in 1973. It must be stressed, however, that the weather conditions preceding the 1975 and 1976 hay harvests differed greatly. The 1975 harvest followed an extremely wet period from autumn 1974 until May 1975 but the 1976 harvest was preceded by very dry weather from the summer of 1975 onwards. It is also likely that the sub-plots sampled in 1973 and 1974 would still be in a state of change induced by the new liming scheme when sampled in 1976.

Comparisons of the effects of the treatments on the botanical composition of the plots at particular dates have, as noted earlier, been made frequently in the past. These elucidated certain general principles but conclusions from many of the detailed comparisons of the percentage composition of the species may inevitably apply only to the specific conditions (e.g. nutrient status, pH) prevailing at a particular time and need not necessarily apply throughout the course of the experiment. Moreover, for many minor components it is not always possible to separate treatment effects, seasonal effects and sampling error. Too much emphasis cannot therefore be placed on comparisons of minor components in particular years nor indeed on the exact magnitude of difference of more abundant species. Comparisons over a number of years should give a better measure of differences due to treatment when effects due to season and sampling error are minimised. Since the major ecological 'truths' have been well established it is now equally important and interesting to ascertain the successional changes that are occurring on the plots. Less attention has been given to this, partly because of the difficulty of assembling the vast amount of accumulated data which extends over 120 years. During the present investigations, however, it became clear that a realistic interpretation of the present-day flora should take account of past changes and to this end all previous data have been put together. (See Tables 7 - 45.) Greater detail is of course available in the original publications; for reasons given earlier it is, however, doubtful whether these tell us much more about the herbage, except on the total number of species on a plot.

METHOD OF SAMPLING AND PLOTS AND SUB-PLOTS SAMPLED DURING 1973-76

Since 1960 tedding the herbage immediately after cutting has left it too fragmented to use for botanical analysis so the method of sampling used in the past could not be adopted. In 1973 and 1974 samples were cut by hand every 2-3 paces from the standing crop about 0.3m to each side of the forage harvester strips (which are cut before the rest of the crop to estimate yield), and also to each side of the centre strip cut for access for studies of the soil and surface fauna by the Entomology department in those years. Four strips are forage harvested on the larger and two on the smaller plots and this enabled sampling to be done along ten transects on the larger and along six on the smaller plots. No centre access strips were cut during 1975 and 1976 so that sampling was done along either eight or four transects. However, the fewer transects in those years, compared with 1973 and 1974, were partly offset by twice the area being sampled as half-plots were sampled in 1975 and 1976 but quarter-plots in 1973 and 1974. Samples were air-dried in a shaded glasshouse and then packed in polythene sheets in the laboratory and analysed during the winter. Approximately 600 g of hay was

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