

An approach to the Agrarian History of Upland Country: Ecology and Habitat*

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THE agrarian history of upland country has not been widely studied and one of the reasons could be, as Estyn Evans explains, that 'one of the attributes of a society which is essentially pastoral is that much of the documentation is lacking'.¹ The consequent lack of information about the social and economic implications of changes in husbandry techniques may be overcome by the application of quantitative ecological methods for, as Sir George Stapledon has argued, 'vegetation accurately read is a remorseless and objective historian'.²

It is argued here that the deficiencies of documentation so lamented by Estyn Evans may be made good by the type of analysis favoured by Stapledon. In this review of ecological methods and studies of the components of upland systems the object will be to establish their relevance to the elucidation of the agrarian history of the British uplands. It should be said here that the term 'upland' is applied *sensu latu* so as to include both upland and hill farming, rather than restricted to definitions of altitude or vegetational status which would here create confusion.

Ecology is concerned with the biological relationships between organisms in a habitat. Investigations take account of the physical environment to the extent that physical factors such as climate, geology, or soil chemistry modify such species interactions. Ecology is a quantitative science in so far as it is concerned to analyse and evaluate

the dynamic processes operating or to describe numerically the vegetational patterns in order to generate explanations for what is discerned. Because man's economic activities are a biological factor in the competitive interactions between organisms, they are of interest to the ecologist so that the distinctions between historical ecologists and ecological historians depend rather more on the application of the study than upon the methods employed. As Stapledon has commented 'There are no disciplines, only problems'.³

Recondite discussion of the mathematical and statistical theories involved in the analysis of vegetation does not seem appropriate here and interested readers are referred to accounts by Kershaw and Greig-Smith.⁴ It should be emphasized, however, that all techniques used in the analysis of pattern should be subordinated to biological considerations. Some explanation of the techniques is required. Numerical studies since the war have contributed to the idea that vegetative pattern is not generally explicable in terms of chance.⁵ The physiology, reproductive strategy, and dispersal mechanisms, the anatomy, morphology, and habit (i.e. whether it grows horizontally (creeps) or vertically (climbs), whether it is tussocky or clumped), as well as its competitive efficiency, all impose pattern.⁶ Clearly the scales at which these attributes are influential differ so that at large scales pattern may be the result of gross environmental

* A glossary and list of plant names is appended to this article.

¹E Estyn Evans, *The Personality of Ireland: Habitat, Heritage, History*, 1972.

²R Waller, *Prophet of the New Age: the Life and Times of Sir George Stapledon*, 1972.

³Waller, *op cit.*

⁴P Greig-Smith, 'Pattern in Vegetation', *Jour of Ecology*, 67, 3, 1979; *Quantitative Plant Ecology*, 1983.

⁵Greig-Smith, *op cit.*

⁶K A Kershaw, *Quantitative and Dynamic Ecology*, 1973; J L Harper, *Population Biology of Plants*, 1978.

factors whilst at the smallest scale it may be explained by spatial exclusion. Plant assemblages may often provide an index of environment and it was observations of species sociology at any type of site which advanced the techniques of classification.⁷ Essentially the species composition at any one site is recorded and analysed so as to derive a form of 'information' statistic by noting presence and absence between sites. Such a process may suggest particular species as 'environmental indicators'. For reasons of computer time a divisive classification is preferred, whilst for ecological reasons an assemblage of species (polythesis) is an advantage. Classification according to a divisive polythetic scheme has permitted ecologists to develop a diagnostic view of species (aut-ecology) or of an assembly of species (synecology) as well as to identify the environmental parameters operating.

Investigation of pattern at large scales required that a reliable means should be found in order to place a species or a site in a graded series (ordinated). To do this, Principal Components Analysis (using P.C.A. as a generic term for a whole range of similar techniques, which is not strictly correct) has been employed, and the information content is calculated in multi-dimensional space in which each element is computed orthogonally to the preceding element. It is a technique which has been of considerable use since it permits the components of variation to be identified. There are many similar techniques and computer programmes available according to requirement but a scheme which uses a process called by its author 'reciprocal averaging' is widely used. This method allows the components of variation between sites and species to be mutually informative simultaneously.⁸ A useful extension of this method, known as Indicator Species Analysis, has enhanced the flexibility of reciprocal averaging by incor-

porating a divisive polythetic classification as a first stage which allows additional sites to be introduced into the analysis without requiring a totally new computation.⁹

A study by Basset of pastures in the Camargue provides an elegant example of how the technique may be used and integrated into a most effective analysis of habitat.¹⁰ He was able to identify differences in habitat which could be explained by differences of management. Similar studies of upland environments by Bunce *et al.*, and by Hill and Jones,¹¹ in which the concern was to identify the appropriate management strategies for economic and conservation purposes could point to variations in habitat which were explicable in terms of past utilization and were documented in maps and estate documents. A similar study of limestone upland in the south Pennines, using a different technique, revealed a pattern caused by human activity.¹² In all cases cited above the vegetative analysis has been complemented by extant documents which suggests the potential of such an approach for historical purposes.

One of the quantitative techniques used to investigate pattern at smaller scales is 'Pattern Analysis', in which species are recorded by contact along a transect and the data processed by a nested block analysis of variance. The data is then plotted as a graph of mean square or covariance against block size which indicates both the scale of pattern as well as the intensity according to the size of the peak. A most appropriate example of such a technique is provided by Chadwick's study of *Nardus stricta* (Mat Grass) on upland in North Wales.¹³ Here a pattern was discerned which could not be explained by

⁷J Braun-Blanquet, *Plant Sociology*, New York, 1932.

⁸M O Hill, 'Reciprocal Averaging. An eigen vector method', *Journal of Ecology*, 61, 1, 1973, p 273.

⁹M O Hill, R G H Bunce and M W Shaw, 'Indicator Species Analysis', *Journal of Ecology*, 63, 2, 1975, p 597.

¹⁰P Basset, 'The Vegetation of a Camargue Pasture', *Journal of Ecology*, 66, 3, 1978, p 807.

¹¹Hill, Bunce and Shaw, *op cit*; M O Hill and E W Jones, 'Changes in a Welsh Forest', *Journal of Ecology*, 66, 2, 1978, p 427.

¹²D J Anderson, 'Studies on structure in plant communities 1. An analysis of limestone grassland in Monks Dale, Derbyshire', *Journal of Ecology*, 53, pp 97-107.

¹³M Chadwick, *Studies of Nardus stricta in North Wales, 1959*, unpubl PhD thesis, Univ Coll Bangor.

environmental variation or independent species characteristics. When additional evidence from economic and social history was introduced an hypothesis could be advanced to explain the pattern. A change in the meat consumption pattern consequent upon the First World War resulted in smaller joints. Where hitherto upland and hill flocks were composed of wethers, smaller joints resulted in a switch to 'fat lamb', which meant that grazing was even more selective with a consequent neglect of *N. stricta*. When the rate of cloning by rhizomes was calculated the scale of the pattern coincided with the process of propagation of *Nardus* since the switch in the composition of flocks. A study of less relevance to upland studies is nevertheless interesting. Harper and Sagar studied the distribution of *Ranunculus spp* (buttercups, in this instance) along a transect of ridge and furrow in grassland of the English midlands.¹⁴ The three species of buttercup showed preference for different types of site on the ridge and furrow so that *R. bulbosus* seemed to flourish at the top of the ridge, *R. ripens* flourished in the furrow, whilst *R. acris* occupied the intermediate sites. These preferences seemed to be related to the water relations and drainage, and this was tested by experiment. The studies of Chadwick, and of Sagar and Harper, illustrate the range of evidence utilized in ecological investigations and they equally suggest historical applications. It is also important to note that such methods of investigation cannot be applied by rote but require a knowledge of species and their competitive capacity. 'Plot-less' patterns of analysis have been developed by Yarranton,¹⁵ and by Stow and Wade,¹⁶ which might have historical applications, but I have no examples to illustrate their immediate relevance.

One of the central concerns of ecology is 'climax'. The concept, grossly simplified, postulates that the interaction of species, habitat, and environment is directional so that at any one stage of development there are typical assemblages which indicate the state of a community towards climax. That is to say that an assemblage of plants on recently colonized ground will create the conditions for different plants to flourish. Each assemblage succeeds its predecessor according to the rate of change created by the competitive interactions of all species present. The implications of 'stability' are that the components of a stable habitat are in a state of competitive equilibrium which militates against substantial further change. The point of equilibrium may be designated a 'climax'.¹⁷ Clearly the more quantitative data which becomes available from studies of any stage or process the better are the chances of constructing a mathematical model by which future and past states may be extrapolated with predictive cogency. Such processes may be modelled using matrix sequences, and Usher has demonstrated its application in a Markov model of succession.¹⁸ Stowe and Wade have employed a similar model with their data from the plot-less pattern analysis to simulate pattern changes.

Grassland may be seen as a frustrated climax of human intervention. The intervention of a selective grazer (sheep) considerably modifies the competitive relationships between species. This pastoral intervention has effects that are compounded and confounded by environmental severity, which make the task of arriving at a viable management strategy more difficult to devise.¹⁹ Such systems have been modelled and a formula has been suggested by

¹⁴ J L Harper and G R Sagar (1953) 'Some aspects of the Ecology of Buttercups in permanent grassland', *Proc British Weed Conference*, 1, pp 256-65.

¹⁵ G A Yarranton, 'A Plotless method of sampling vegetation', *Journal of Ecology*, 54, 1966.

¹⁶ L G Stowe and M J Wade, *Communities and Eco-systems*, 2 edn, 1975.

¹⁷ R H Whitaker, *Communities and Eco-systems*, 2nd edn, 1975.

¹⁸ M B Usher, 'Markovian models in Ecological Succession', *Journal of Animal Ecology*, 48, 2, 1979, p 413.

¹⁹ P A Gething, P Newbould and J B E Patterson (eds), 'Edinburgh-Henley Hill Pasture and its economic utilization', 3rd Colloquium of the Potassium Institute, 1972; D A Jenkins, E R B Oxley and P A Gething (eds), 'Bangor-Henley Marginal Land: Integration of Competition', 4th Colloquium of the Potassium Institute, 1974.

Noy-Meir which can take account of differential effects as a result of different stocking policy.²⁰ Ecology should not therefore be considered to be field biology for mathematicians but as a synthesis of biological studies in an attempt to comprehend the integral calculus of a living system. In an approach to agrarian history it should not be considered to be a peripheral adjunct but as central and integral to such enquiries.

The upland systems of the British Isles are of considerable importance and have been recognized as such since remoteness and self-sufficiency have been associated with meditation and sanctity. The ecology of these systems has been of interest for many years. The highland regions of Scotland and the central mountain massif of Wales have been studied extensively, either because they are districts of interest for students of Alpine flora or because they are semi-natural wildernesses where the apparently conflicting needs of efficient management and conservation need to be reconciled.²¹ The 'anthropogenic factors' in these systems are of considerable importance as identifying the extent to which man as a pastoralist, miner, forester, or as a sportsman has affected the eco-system. Much of the chronology of man's involvement has been provided by palynology.

Turner, Moore and Chater, and Pennington²² have utilised columns of bog section to analyse the pollen components vertically and deduce from those assemblages what type of habitat and environment was prevalent at any one time. This analysis is calibrated by using ¹⁴C isotope in radio dating, although that isotope is of little use for recent times. There is clear evidence of man's activities in these systems provided by the nature and frequency of species iden-

tified; an intervention which can be distinguished over 5000 years. Turner compared her sections of a Tregarron series with sections from East Anglian Fen and ventured, on the basis of the contrast between the two, to formulate a pastoral/arable index which was derived from calculating the frequency of *Plantago* species as a percentage of total *Plantago* Compositae, *Artemisia*, *Chenopodiaceae*.²³ Where this percentage was high (between 52 and 70) it is taken as indicative of grassland and grazing as well. A species such as *Pteridium aquilinum* (bracken) provides also some indication of the quality of the grassland over the period. The variations in tree pollen also permitted the sequence of clearing to be fixed. Her scheme suggests the nature of pastoral management as well as providing a chronology. It is of interest that her study was able to distinguish a period of arable cultivation which coincided with the Napoleonic wars and which faded out completely in the 1870s when there was agricultural depression.²⁴

A similar picture emerges from the study by Moore and Chater. They are able to confirm their sequence with documented episodes in Welsh economic history. Both sets of workers suggest that the traditional tribal transhumance practised in Wales was severely modified or defunct in the early middle ages at about the same period as monastic influence becomes apparent. There will be occasion to refer to this at a later time.

Elner and Wood, Guppy and Wood, Wood and Liddle *et al*²⁵ studied sediments of fresh water mountain lakes and thereby the past and present ecological state of such lakes. They have been able to determine the nature of human activity on the river

²³ Turner, *op cit*.

²⁴ P J Perry, *British Agriculture 1875-1914*, 1973.

²⁵ Janet R Elner and C Hapley-Wood, 'Sediment cores from two linking and contrasting lakes in Wales', *Br Phycological Jour*, 13, 4, 1978, p 41; S F Guppy and C Hapley-Wood, 'Sediment cored from two linked lakes in North Wales', *Freshwater Biology*, 8, 1978; C Hapley-Wood, 'Distinctions in algal ecology and production in two linked lakes in North Wales', *Ver Int Limnology*, 19, 1975, p 1045; M J Liddle *et al*, 'A Survey of the biota, environment, and use for recreation of 12 lakes in Snowdonia', *Biol Jour of Linnean Soc*, 11, 1979.

²⁰ I Noy-Meir, 'A Grazing Model', *Jour of Applied Ecology*, 15, 3, 1978.

²¹ Jenkins, Oxley and Gething, *op cit*.

²² J Turner, 'The Anthropogenic Factor in Vegetation', *The New Phytologist*, 52, 3, 1964; P D Moore and H G Chater, 'The Changing Vegetation of West-central Wales in the light of human history', *Jour of Ecology*, 67, 2, 1969, p 361.

catchment areas. A similar picture has been obtained by Seddon in his study of fresh water macrophytes.²⁶ Elnor and Wood studied the cysts of *Algal genera* to obtain an indication of the population structure, and thus the nutrient status, of the two linked lakes, Llynys Peris and Padarn. Guppy and Wood examined the chemical system of the sediments by which slate quarrying, mining, and human demography could be dated. These studies were able to recognise the subtle (and not so subtle) changes in human activity, including the advent of tourism, which is signalled by the increased input of nitrates and phosphates with concomitant changes in species structure. This change of nutrient status from 'oligotrophic' to 'eutrophic' had been reflected in the population composition and frequency of the algal cysts in the sediment. Liddle *et al* used biological indicators (alga, fresh water invertebrates, and macrophytes) to study the status of twelve Snowdonian lakes in order to assess their condition in terms of prospective recreational use. Their study was ordinated using the indicator species analysis ordination, which suggests how a combination of biological and statistical techniques contribute towards a flexible quantitative approach to a wide range of problems in ecology, human geography and social history.

Entire upland systems have been studied, and it is interesting to appreciate how the significance of environmental factors can be estimated as a result of such projects being pursued in a wide range of locations. Hughes, Ratcliffe, and Edgell²⁷ studied the north-west Conway Valley (1946), the Carneddau (1959), and Cader Idris (1961) respectively. Edgell comments to the effect that it is 'interesting how upland systems

resemble each other despite being widely diverse in geography and geology. He makes the comparison between his own study and those of Hughes and Ratcliffe, pointing out how similar are their results despite the greater oceanic influences operating on Cader Idris.

Ratcliffe developed an interesting schematization of the relationships between soils, vegetation, aspect, and biotic pressure which he derived from his studies of the Carneddau. It was a good area for such a study since the uniformity of geology and climate allowed the biotic consequences of grazing to be separated from the environmental influences; these are often confounded. His scheme is similar to that of Hughes in the Conway valley, who used a suite of soils as an environmental indicator of rainfall and biotic gradient. These studies for North Wales have general support from studies of other British upland regions, and in this respect the studies of Wyllie Fenton are interesting and notable.²⁸ He was alert to the implications of human activity, which he discusses in two papers for the *Scottish Geographical Magazine*. The study of vegetation which he offers is associated with specific changes in management strategy. He, too, observes how biotic pressure by grazing has contributed to the deterioration of upland rough pasture, so that he is able to relate an instance of a change from a balanced grazing stock with cattle to sheep to a definitive vegetative analysis. The study lends cogency to a diarist's lament: 'Our mountains which were of old pastured by black cattle are now pastured only by sheep'. *Nardus stricta* (mat grass) and *Molinia acuticulata* appear at the expense of finer species. In a more concisely ecological paper he is able to support his generalizations by ecological evidence of historical significance and relevance.²⁹

²⁶ B Seddon, 'Aquatic macrophytes as limnological indicators', *Freshwater Biology*, 2, 1972, p 107; 'Report on the organic deposits in the pool of Dinas Emrys Savery', *Arch Cambrensis*, 109, 13, 1960.

²⁷ R E Hughes, 'The Vegetation of the North West Conway Valley', *Journal of Ecology*, 37, 1959, p 306; D A Ratcliffe, 'Environment and Vegetation of the Carneddau', *ibid*, 47, 2, 1959, p 388; M C R Edgell, 'The Ecology of an upland sheep walk on Cader Idris', *ibid*, 50, 1961.

²⁸ W Fenton, 'Vegetation of upland environments', *Scot Geog Mag*, 1933; 'Vegetation and Grazing Management', *ibid*, 1937; 'Vegetation and Grazing in the British Uplands', *Journal of Ecology*, 25, 1937.

²⁹ Fenton, *op cit*.

Milton's studies of upland grass agromony are also of interest. By the establishment of experimental plots and by sustained recording of the changes observed during some thirty years he provided scientific cogency to explanations of how paradises are lost and regained.³⁰ Milton controlled grazing, and he applied nutrients to sample tracts of upland pasture at three different locations. The sites were at comparable altitudes (950 ft, 290 metres). At a site at Bwylchrosser there was a sward of fescue bent together with some lowland species whilst there was no *Nardus*, *Molinia*, *Vaccinium* (bilberry) or *Calunna* (heather). At a site at Llety, at the same altitude, there was a typical upland fescue sward in which there were some bents, as well as traces of *Molinia*, *Nardus*, *Vaccinium*, and *Calunna* but no lowland species. At a further site at Llety there was a *Molinia*-dominated sward containing some fescue, but also *Nardus*, *Carex* (sedges) and *Juncus* (rushes). The soils could be considered similar as regards exchangeable lime, potash, and phosphate. The experimental treatments were as follows:

Experimental treatments

- (a) No fertilizer
 - (b) Superphosphate at 42 cwts/acre/assnum
 - (c) Ground limestone at 2 tons/acre/per five years
 - (d) Superphosphate, Kainit, and, Sulphate of ammonia at ratio 4:4:1 respectively (PKN)
 - (e) As for (d) plus 2 tons limestone every fifth year
- NB At each centre, ie Bwylchrosser and Llety 1 and 2 there were a series of plots which were fenced to facilitate individual grazing of each plot on a monthly grazing regime during the season (April–October). Another series was unfenced and thus open to grazing. At Bwylchrosser grazing included cattle.

The results are not easily summarized since many detailed changes are of considerable ecological interest. Some of the salient points may be discussed because they do suggest a number of elements in the argu-

ment which connects ecology with agrarian history.

Herbage production increased at all the centres as a consequence of controlled grazing. The greatest increase was on those plots at which PKN were applied and on those on which additional limestone was applied. The seasonal distribution of growth was also improved. The most interesting changes effected were those of botanical composition. On the Llety *Molinia* sward (Centre 2), which could be considered an example of poor quality grazing, there was no ingress of lowland species on the unfertilized plots irrespective of grazing regime. Under open grazing with additional nutrients the sward changes were quite small during the first fifteen years but in the latter years of the experiment the *Molinia* component fell appreciably to be replaced by *Festuca ovina* (sheep's fescue) and *Nardus stricta*. This change could be attributed to the change of management during the years of the Second World War. In the fenced area the decline in *Molinia* occurred during the first five years where it was replaced by *Festuca ovina* and *Agrostis tenuis* (bent). During the next twenty years bent species replaced the fescue. In the fertilized and controlled swards lowland species became established during the first five years. The subsequent changes, depending upon fertilizer treatment, are remarkable and may be summed up as a transformation of an upland sward to a quality comparable with a lowland sward, including lowland species, both grasses and herbs, bent, white clover (*Trifolium ripens*) and red fescue (*Festuca rubra*). The close attention to sward composition as well as the sustained length of experimental observations is of interest for economic future of the uplands but its value for the analysis and interpretation of historical processes is also clear. The results of species composition at the Llety no. 1 site and at Bwylchrosser are also of interest, but since this review is more concerned to illustrate the type of studies with a few examples of results which illuminate the ecological approach

³⁰ W E J Milton, 'Grazing and species composition', *Jour of Ecology*, 38, 1940; 'Further Observations on grazing and species', *ibid*, 46, 1948.

there is no need to elaborate. The significance of the above results will become clear in later discussion.

The study was of greater significance when sheep performance was also studied. The standard rate of growth, the net weight gain, and the lambing rate were increased significantly on the improved plots,³¹ and it could be said that the difference in the viability of any farm could be altered, yielding profit rather than persistent loss.³² This is demonstrated when comparisons are made with contemporary farms in Ireland. Net weight gains of some 10 pounds are recorded on improved pastures, whilst the survival rate and the birth rate of infant lambs were increased from approximately 1.3 to 1.9–2.0, and from 0.7 to 1.9 respectively. The effectiveness of these findings has been supported by the practical improvements wrought at Fassfern (Aberdeenshire). The studies of Milton have confirmation from studies in Cumbria,³³ and from Scotland.³⁴ In the Scottish study the relationship between vegetation, soil status, and grazing regime has been noted by Nicholson and Robertson so that in 1958 they are able to write: 'The available evidence suggests that the influence of man and animals in comparatively recent times has been considerable. . . . For some years prior to 1944 balanced grazing has not been practised.' King, in his study of a *Festuca-Agrostis* grassland,³⁵ is able to comment that not all grasslands are equally susceptible to the incipient encroachment of *Nardus* but that all 'Low soil base status or increased soil moisture are predis-

posing factors', or as a result of 'selective sheep grazing'. Welch and Rawes studied the effect of two levels of cutting on an upland sward in Cumbria, the first cut at 3–4 cm and the other at soil level (the latter being an approximation of the level at which sheep graze). It was possible to distinguish the nature of the differences in an unseeded regeneration. Park *et al* had experimented with transplanting and survivals in the same area and were able to build up a picture of the environmental potential of species independent of grazing.

Studies of grazing patterns and the behaviour of sheep have obviously considerable relevance. Hunter has studied the home range behaviour of Cheviots together with their sward preferences and the associated vegetational changes, on a traditional 'weft' grazing policy in which there are nine distinguishable qualities of sward (by a criteria of vegetative composition). Differences according to season were also noted.³⁶

The studies discussed hitherto have been concerned with aspects of vegetation in upland environments as well as of the role of sheep in modifying that composition. Studies into the grazing behaviour of cattle and goats (and deer which have been overlooked here) have not been mentioned, but Milton's study at Bwylchrosser, and Milner *et al*,³⁷ who studied feral goats in Wales, indicate that neither of these animals is as selective in their grazing as are sheep. The flocking behaviour of sheep is also of interest because of the flushes they create by their urine and dung at the sites of night camping. At these sites noticeably luxuriant growth occurs where nutrients have been concentrated, and this process is important. There are metabolic differences between adult and lamb so that there is a differential rate of nutrient retention of the lamb which retains Ca and P to a greater extent than the adult. Clearly in a

³¹ I L Jones, *Studies on Hill Land in Wales*, Tech Bull no 2, Univ Coll Aberystwyth Welsh Plant Breeding Station, 1967.

³² J P Newton, 'The Future of the British Uplands', in CAS Paper 2, *Farming and Forestry in the Hills and Uplands*, 1977.

³³ M Rawes and D Welch, 'Upland Productivity of Vegetation and Sheep at Moor House National Nature Reserve Westmorland', *Oikos Supplementum*, 11, 1, p 72; D Welch and M Rawes, 'The early effects of excluding sheep from high level grassland in the Northern Pennines', *Journal of Applied Ecology*, 1, 1, 1964, pp 281–300; K J F Park, D Welch and S E Allen, 'Studies in Upland Grazing', *Journal of Ecology*, 50, 2, 1962, p 260.

³⁴ I A Nicholson and T Robertson, 'Soils and Vegetation in North East Scotland', *Journal of Ecology*, 46, 2, 1958, p 260.

³⁵ T King, '*Festuca agrostis* grassland in South East Scotland', *Journal of Ecology*, 49, 2, 1961, p 350.

³⁶ R F Hunter, 'The Grazing of hill sward types', *Journal of Grassland Assoc.*, 9, 1954, p 195; 'Hill Sheep and their Pasture', *Journal of Ecology*, 50, 3, 1962, p 651.

³⁷ C Milner, R Goodier and I G Crook, 'Feral Goats in Wales', *Nature in Wales*, 11, 1, 1968, p 3.

situation where the lamb is removed from the pastures early there is a greater loss of nutrients than when the adult is retained.

Where there is burning and clearing of bracken for either sheep grazing or for sport the resulting patterns may be analysed by pattern analysis, whilst further investigation can identify the age structures, and cycles of competition between bracken and heather have been demonstrated by Watt, Gimmingham, and Barclay-Estrup.³⁸ Watt has studied a whole range of such cycles which have proved a powerful conceptual basis for contemporary research into population and quantitative plant studies. Greig-Smith has pointed out how human activity may perpetuate a single age cohort for many generations after the original episode of burning or clearing. An example of such interference has been provided by Anderson in his study of limestone grassland in Derbyshire.

Studies of plant populations over a long period are of considerable value. Tamm in Sweden studied survivorship and floristics of a meadow which had been divided and had been subsequently managed in two distinct ways (grazing and mowing).³⁹ Similar studies have been pursued over a shorter time scale by the School of Plant Biology at UCNW Bangor. Tamm's studies provide a very good indication of how habitat changes wrought by man interact with specific traits to influence species composition at individual sites. Such studies also demonstrate how an ecological approach to agrarian history is not merely a matter of borrowed technique but imply an integrated biological understanding of a habitat in which men have intervened.

The deliberate use of ecological methods to investigate problems of upland agrarian history are illustrated by the studies and observations of R Alun Roberts and R E Hughes.⁴⁰ Studies of the relationships of the managed habitat and environment in Snowdonia by these two men extend back over fifty years of intimate acquaintance with all aspects of Snowdonia. They are studies which remain stimulating and vital contributions to historical investigation of Snowdonia's social and ecological history; they are also a splendid refutation of the excessive specialization of disciplines. At a summer meeting of the British Ecological Society in 1934 there was an excursion to Cwm Idwal in Snowdonia. On that occasion R A Roberts explained how the vegetation of the area was explicable in terms of its recent management history. The observation of *Nardus stricta* and *Molinia spp* was, he argued, a direct consequence of the enclosure movement during the late eighteenth and early nineteenth centuries which had destroyed balanced grazing hitherto in use and contributed to the increased intensity of sheep grazing and the associated neglect of upland cattle and goats. He recalled that sheep had been less intensively grazed during the middle ages and were introduced during the sixteenth century. The enclosure movement, he argued, destroyed the modified pattern of 'transhumance' which had survived relatively intact with livestock being

³⁸ A S Watt, 'Pattern and Process in the plant community', *Journal of Ecology*, 35, 1947; 'Bracken versus Heather: a study in plant sociology', *Journal of Ecology*, 43, 2, 1955, p 490; P Barclay-Estrup and C H Gimmingham, 'Vegetation Change in relation to the Calluna cycle', *ibid*, 57, 3, 1969, p 737; H Gimmingham, 'The effects of grazing on the balance of *Erica cinerea* and *Calluna vulgaris*', *ibid*, 37, 1, 1949, p 109.

³⁹ C O Tamm, 'Composition and Vegetation in grazed and mown sections of a former hay meadow in Sweden', *Oikos*, 7, 1956, p 144.

⁴⁰ R Alun Roberts, 'Report on B.E.S. Summer Meeting in Bangor', *Journal of Ecology*, 23, 1935, p 252; 'Agricultural Ecology', Univ Coll Bangor, Roberts Papers, Bangor MS 20081; 'Ecology of human occupation and land use in Snowdonia', *Journal of Ecology*, 47, 2, 1959; R E Hughes, 'Ecology of Snowdonia: ecology of live stock production', *Nature*, 176, 1955, pp 595-6; 'Sheep Population and Environment in the mountains of North Wales', *Journal of Ecology*, 46, 1, 1958, p 169; 'Studies in Sheep Population and Environment in North West Wales', *Journal Applied Ecology*, 10, 1, 1973, p 107; R E Hughes, J Dale, L Ellis-Williams, and D I Rees, 'Studies in Sheep Population and Environment in the mountains of North West Wales: status of sheep since medieval times', *ibid*, 10, 1, 1973, pp 113-72; R E Hughes, J Dale, M D Mountford, and L Ellis-Williams, 'Studies in Sheep Population and Environment in the mountains of North West Wales: contemporary distribution of sheep populations', *ibid*, 12, 1, 1975, pp 165-78; R E Hughes, J Lutman, A G Thompson, and J Dale, 'A Review of density and ratio of sheep and cattle in medieval Gwynedd with particular reference to the uplands', *Journal Merionedd Hist and Rec Soc*, 7, 4, 1973.

transferred to the hafod (summer farm) from the hendref (winter farmstead). The contemporary importance of winter grazing was emphasized by MacLeod, speaking in his capacity as a representative of Scottish upland farmers at a colloquium in Edinburgh, when he observed that the challenge to expertise still remains that of winter grazing. Roberts implies that the structure of transhumance remained intact throughout the sixteenth and seventeenth centuries as well as in the early eighteenth century, and insists, moreover, that the system was balanced as well as being 'wiser' than the 'efficient' intensive policy developed subsequently. Shades of this analysis can be found in Chadwick's explanation for *Nardus stricta* pattern, for Roberts can also point out the disastrous ecological consequences for upland pasture created by 'fat lamb' which impoverishes the nutrient status of the soil, and *ergo* the quality of the sward. He develops his argument further in his paper on 'The Ecology of Sheep Farming in Snowdonia', as well as in an earlier address to the British Association.⁴¹

R E Hughes has been equally interested in applying ecological expertise to the problem of upland pastures. Papers on the problems of human intervention into the environment have been appearing since 1940. In two recent papers Hughes *et al* have studied the status of sheep in Snowdonia since the middle ages through to the present where they have placed in perspective the present distribution and intensity of sheep populations.⁴² The general findings of Roberts and Hughes are apposite here. Essentially Hughes does not subscribe to the Roberts thesis. His historical studies suggest that within the upland region of Snowdonia (*sensu latu*) the ratio of sheep to cattle has always been higher. From monastic records and extrapolations from evidence of the

medieval wool trade he estimates this ratio to be 1.6:1, compared with a figure for Wales as a whole of 2.5:1. In the more mountainous districts of North Wales the figure varies between 10.1:1 and 21.1:1. Subsequently this figure rises to between 21.1 and 52.1:1 by 1969. These figures conceal further subtle variations. At Bodelwyddelan, on the Wynn estate, the figure of 10.1:1 may be compared with a figure of 21.1:1 at Llanberis. During the eighteenth century the comparable figures are 31.1:1 and 51.1:1 respectively.

There are other difficulties with these figures. They conceal demographic and economic fluctuations as well as the problems of defining 'rough pasture' and 'summer grazings'. Diaries and estate accounts of the Wynn estate at Gwyddir also raise the problem of the extent of pasture at any one time. The studies of Turner and of Moore and Chater would seem to confirm the estimates of Hughes and to challenge the arguments advanced by Roberts.⁴³ The evidence suggests that there was no discontinuity during the late eighteenth century but that the ratio of sheep to cattle was rising as part of a continuous trend from the sixteenth century onwards. The change in ratio, however, does not suggest the origin of the change. Not all the variations can be explained in terms of a decline in the stocking of cattle alone nor does documentary evidence suggest it to be the case. There is certainly documentary evidence and ecological evidence for the assertion that sheep have been intensively stocked to an increasing extent since c.1800. We have thus a problem of interpretation which is not easily resolved. Hughes believes that the evidence provided by the Cistercian monastic pastures is not broadly applicable, and there would appear to be support for this from the ecological studies of Turner and Chater and Moore.

Contemporary evidence is also capable of influencing historical interpretation.

⁴¹ R Alun Roberts, 'Report', *op cit*; 'Agricultural Ecology', *op cit*.

⁴² F V Emery, 'The Farming Regions of Wales', in Joan Thirsk (ed), *Agrarian History of England and Wales*, IV, 1967; E L Jones, 'Environment, Industry and Agriculture', *Jour Agrarian Hist*, 1977.

⁴³ Turner, *op cit*; Moore and Chater, *op cit*.

Hughes *et al* have used evidence of a sheep census taken continuously since 1956 during the summer grazing period of April to October. A complex picture of grazing, vegetation, and environment has been tested statistically and there seems reason to argue that grazing is dependent upon a gradient inversely proportional to rainfall, acidity of soil, geological parental material, and altitude. This study raises many questions. What it suggests immediately is that Roberts's thesis is too simplistic and that his documentary evidence is not drawn from sufficiently representative samples. The thesis that goats played a more significant part in the grazing of Snowdonia is not supported by the inventories of stock cited by Emery, where goats hardly featured at all, and indeed some of the ecological studies suggest that some of the ideal sites for goat grazing had not been so grazed despite the presence of feral herds.

Ecological history is perhaps producing the first historiographic argument on upland agrarian evidence, and indeed one where the ecological evidence is central to the resolution of the dispute. It is hoped the problem will be discussed in a later paper in which the integrated work of Hughes will be discussed in closer detail and the ecological facets of Roberts's thesis will be examined accordingly.

The environmental evidence does not feature in agrarian historical studies. The latest volume of the Cambridge *Agrarian History* discusses the uplands (*sensu latu*) quite tersely. Mention is made of the improvements in the quality of upland pasture innovated by Stapledon and Bligh and pioneered in the Cahn Hill scheme. There is brief mention there of the changes in the structure of the flock resulting from the switch to 'fat lamb', but the significance in the process of deterioration of these changes is scarcely appreciated. Brief mention is made of these changes by Stamp and Darling: the former in his commentary in the *Land Utilisation Survey*, and the latter in his

monograph on *The Highlands and Islands*. This ecological approach to upland agrarian history is often intimated or implied whenever there are studies of the impact of human agencies upon environment whilst there has rarely been a full appreciation of the potential of quantitative ecology as a technique in investigations of upland agrarian history. E L Jones writes:

Among historians only the Annales School in France, and in the English speaking world a few professionals, not professional Agrarian Historians have shown much awareness of the interplay of different Eco-systems with the presence of long term economic change.

The view receives support from Le-Roy Ladurie, who recognises that ecology is part of the 'Territory of the Historian'.

This paper seeks to recommend to agrarian historians the range of ecological expertise and technique available for the enquiry into upland agrarian history. It is hoped that a further paper will consider some work which exemplifies the value of such an approach, and there would also appear to be scope for evaluating the value for agrarian history of the extant resources contained within past journals of agricultural science as well as re-appraisal of traditional sources which could assume new significance when placed into juxtaposition with new evidence. This review has been concerned to describe some of the techniques available to ecologists concerned with the condition of past habitats and historic environments. Where the elucidation of these conditions requires the knowledge of economic management the scrutiny of historical documentation is clearly essential. It is often the case that such historical documentation assumes new significance once ecological processes are understood. It is hoped that these indications of the state of ecological knowledge of upland systems and the range of work accomplished has been communicated (although necessarily rather summarily) so that there is a basis for further discussion between the several disciplines which con-

verge and interdigitate when they focus upon the complex of economic, cultural, biological, and environmental factors which constitute upland agrarian history.

GLOSSARY OF TERMS USED

DIVISIVE CLASSIFICATION

A means of classifying sites by species, in which the total species complement is divided into sub-groups on the basis of presence or absence to derive an information statistic.

POLYTHETIC

A classification system which uses a range of criteria (ie species) as a basis for division.

DIVISIVE POLYTHETIC

A classification which combines both the above characteristics.

COMPETITION

This concept is at the very basis of evolutionary theory. The competitive interaction between species is the dynamo in evolutionary change and the study of implications of evolution for physiology, morphology, and population genetics is fundamental to ecological theory.

BASE EXCHANGE

EXCHANGEABLE BASES

Soils are classified in terms of their physical and chemical characteristics. Among the chemical criteria is pH (dissociated hydrogen ions in solution). Ions of other chemical elements PKN, Ca, Mg, present in the parent rock or in the soil are essential for nutrition. Thus the reactivity of these ions in the soil (their capacity to release or exchange ions) is a critical aspect in the evaluation of a soil.

ENVIRONMENT AND HABITAT

Used here to distinguish the factors at a site which originate from the climate and the physics and chemistry of soil and parent rock (environment) from factors consequent upon the interaction of organisms in an ecological community. The terms have no absolute delineation.

MATHEMATICAL (MARKOV) MODELS

Models in which measured values are derived for biological and environmental processes so that the entire system may be investigated mathematically. The models which seek to deal with many processes over time employ matrices among which number Markov models.

¹⁴C

An isotope of the element carbon: the proportions of the isotopes of carbon with half lives of some 5000 years are useful for dating.

APPENDIX OF PLANT NAMES

<i>Scientific name</i>	<i>Vernacular</i>
<i>Nardus stricta</i>	mat grass
<i>Ranunculus repens</i>	creeping buttercup
<i>acris</i>	meadow buttercup
<i>bulbosus</i>	bulbous buttercup
<i>Plantago species</i>	plantains
Family Plantaginaceae	
Family Compositae	family of herbaceous or woody plants among which number the Rag worts and Groundsels
Cruciferae	Annual or perennial herbs (rarely weedy species) among which number radishes, mustards and such plants as Lady's smock
Genera Artemisia	A genera of the Compositae including mugworts and wormwoods
Chenopodiaceae	Annual or perennial herbs, among which number Good King Henry, Fat Hen, Goosefoots, and Oraches
<i>Pteridium aquilinum</i>	Bracken fern
<i>Calluna vulgaris</i>	Heather; so also are the Ericas (Family Ericaceae)
<i>Molinia caerulea</i>	Purple moor grass. Known also as 'flying bent' but that latter name is misleading. A deciduous grass
<i>Vaccinium myrtillus</i>	Bilberry
<i>Carex species</i>	Sedges. The most frequent on upland habitats discussed is <i>Carex flacca</i>

Juncus species

Rushes. Amongst the rushes associated with wetter upland habitats is *Luzula campestris* but it is not limited to uplands. Vernacular: 'weeps brush' or field woodrush

*Other grasses**Agrostis* species

Bent grasses

Festuca spp

The fescues, ie *F rubra* — red fescue, *F praetensis* — meadow fescue, *F ovina* — sheeps fescue

Deschampsia flexuosa

Wavy hair grass

NB. The standard flora for Great Britain is Clapham, Tutin, Warburg. *Flora of The British Isles* published with separate volumes of black and white drawings.

Notes and Comments

WINTER CONFERENCE, 1983

The Winter Conference was held on Saturday 3 December 1983 at the Institute of Historical Research, Senate House, London, on the theme 'The Urban Consumption and Marketing of Agricultural Produce'. As in previous years, the conference was held jointly with the Historical Geography Research Group of the Institute of British Geographers, and 55 members of the two groups attended. Papers were presented by Dr R H Britnell (University of Durham), 'Agricultural trade and the market place in medieval towns'; Dr J A Chartres (University of Leeds), 'The modernization of agricultural marketing after 1640'; Dr G Shaw (University of Exeter), 'Food supply in Victorian cities'; and Dr P J Atkins (University of Durham), 'A comparative study of marketing and consumption in London's dairy and fruit and vegetable trades circa 1800-1914'. The Society is grateful to Dr Overton, who made all the arrangements for the conference, and who continued the successes of our previous organizers, and to the Director and staff of the Institute of Historical Research for providing accommodation for the conference.

ECONOMIC HISTORY SOCIETY CONFERENCE, 1983

The last dozen copies of the pamphlet produced by the Society for the last conference of the Economic History Society, containing four papers on agricultural history, are available from the Secretary, price £2 post free. Details appeared in the last issue of the *Review*.

SPRING CONFERENCE, 1984

The next Spring Conference will be held at Charlotte Mason College of Education, Ambleside, Cumbria, 9-11 April 1984. The programme is as follows: Mr William Rollinson (University of Liverpool), 'Aspects of Rural Life in Cumbria in the 17th, 18th and 19th centuries'; Dr John Langdon (University of Birmingham), 'Horses and the Development of Farm Transport in Medieval England'; Mr Donald Woodward (University of Hull), 'Life on a Yorkshire Estate in the 17th century: Henry Best revisited'; Dr Peter Solar (University of York), 'Irish Agriculture in the Early 19th century: a Reappraisal'; Dr Tony Phillips (University of Keele), 'Farm Building Provision in England, 1850-1900'; and Professor Jeremy Elston (University of Leeds), 'An agronomist's attempt to explain the changes in the yields of wheat in England and Wales from 1886'. Mr Rollinson will lead an excursion into the countryside around Ambleside on the afternoon of 10 April. The programme and booking forms are inserted into this issue of the *Review*. Any enquiries about the Conference should be addressed to the Secretary of the Society.

ANNUAL GENERAL MEETING, 1984

The 33rd Annual General Meeting of the Society will be held at 9.15 am on Tuesday 10 April 1984 at Charlotte Mason College of Education, Ambleside, Cumbria. Nomination forms for the officers and members of the Executive Committee are inserted into this issue of the *Review*, and nominations should reach the Secretary no later than Tuesday 3 April 1984.