6 Comparison with previous data

Previous quadrat data from English Nature Phase II surveys carried out in 1991-2 were available for many of the sites studied, but the ability to make direct comparison was limited by the following constraints.

1. Previous data were in DOMIN format as opposed to the cell counts used in this study.

2. Usually, only one or two quadrats were recorded in each patch of homogeneous vegetation, too few for statistical comparisons to be made.

3. Occasionally it appeared that the second of two quadrats had been placed in an unusual patch in order to define it, further limiting direct comparison.

In view of these limits, especially numbers 2 and 3, formal analysis has not been attempted, but attention is drawn to any apparent major changes in the Discussion.

4 Findings

4.1 Data characteristics in relation to the NVC

The level of overall similarity of the data set with the MG5 data used for the NVC gives some indication of how widely the results will be able to be applied. Restriction of the study to one county might limit its application, but if all the important species of MG5 are represented in approximately the same abundance as in the NVC, then this study might be applicable to such grasslands wherever they occur.

1 Species richness in quadrats

Previous data from sites recorded in this study contained a range of from 11 to 38 species in $4m^2$ samples, while this study revealed a range of from 12-36 species in $1m^2$ samples. The NVC data set recorded a range of from 12-38 species in $4m^2$ samples. Although Bioscan has not previously carried out a direct comparison with MG5 grassland, this result reflects the patterns seen when both methods have been available on calcicolous grasslands. The cell count method tends to reveal at least as many species in one square metre as Domin cover estimates do in samples four times the size.

In effect this means that sites where species diversity has apparently decreased may give cause for concern: apparent increases in species diversity are less likely to be real. The apparently high diversity from this study does not limit its applicability to MG5 grasslands elsewhere.

2 Constancy in comparison to the NVC

A total of 117 species was recorded in 210 quadrats, including all those with a constancy of II or greater in the NVC tables for community MG5. Only seven species with constancy I in the NVC were not encountered in the quadrats. Table 5 shows the constancy of all species in this study compared to the NVC. A perfect match would have all the entries on the diagonal.

The two sets of data are similar, but species in this study had a slight tendency to be more constant than in the NVC. This feature is probably associated with the same mechanism which caused richness per quadrat to be greater in this study. Also, the narrow geographical range of this study compared to the NVC will limit the similarity expected between the data sets.

The presence of a large number (52) of sparse species detected in the study but not listed in the MG5 data tables in the NVC is of little consequence. First, the NVC tables did not list species sparse (in less than 5% of quadrats) in the data for particular sub-communities. Second, many of these species will be revealed as those indicating "damage". Likewise, some of the other differences in relative constancy reflect the deliberate inclusion in this study of grasslands managed in a way which would be suspected to cause damage.

Table 5: Relative constancy compared to the NVC						
Study NVC	V	IV	III	II	I	<I
V (81-100%)	3	5				
IV (61-80%)	1	1	4			
III (41-60%)		1	4	1	1	
II (21-40%)			3	9	5	
I (<=20%)				5	22	52
0					7	NA

Similarly, the seven species listed in the NVC tables for MG5 but missing from this study are of little consequence. All are sparse species and two would not be expected or are very rare in MG5 in Worcestershire (the lady's mantles *Alchemilla glabra* and *A.xanthochlora)*. The remaining five (*Carex panicea, Colchicum autumnale, Festuca arundinacea, Juncus effusus, Knautia arvensis)* were all seen in MG5 in at least one study site but were sparse and did not happen to occur in quadrats.

3 NVC position relative to DCA ordination

Figure 2 shows the scatter of quadrat positions from this study on the first two axes (most important sources of variation) of DCA ordination, compared to the position of the dummy NVC samples for MG5A, B and C. The NVC samples are well within the main cluster of points, showing that the data set in this study contains and brackets the variation expressed by the three subcommunities. This confirms that the study sites covered a good and comprehensive range of MG5 grasslands. This is further supported by the distribution of species positions in the same ordination (Figure 3) because diagnostic species are clearly well spread in appropriate directions for their subcommunity positions.

Despite this, the NVC samples are not central, but eccentrically placed. Part of this may be due to the limits of translation between the DOMIN/constancy values and cell counts, and the restriction of dummy samples to the commoner species. Some is due to the management variation which is the point of this study. Figure 4 shows the central part of Figure 3 expanded with the influence of environmental variables superimposed. The action of variables is expressed by arrows or points[2]. The longer the arrow or further away a point is from the centre where all arrows meet, the stronger the effect. Variables act in the direction to which they point from this centre. For instance, *Lathyrus pratensis* (LATHPRA) appears to dislike northern sites up hills but is associated with taller swards where a hay cut is taken.

2 Strictly, nominal variables (e.g. hay cut vs. no hay cut) are shown by their centroids, quantitative variables (e.g. northing) are shown by their biplot arrows.

4 Species discrimination

Especially in closely grazed vegetation and in the rapidly drying conditions of summer 1995 with the work load having to be spread over two months, some species pairs proved difficult to discriminate reliably. Where flowering material was available, there was little problem, but where only close-grazed or dry vegetative material was present, the following species pairs proved difficult and have effectively been combined for analysis.

The grasses *Poa trivialis* and *P. pratensis*.

Carex species in limited circumstances (except for *C. hirta* which is always distinctive). In most cases, some flowering material was available for checking.

The cinquefoils *Potentilla erecta* and *P. anglica*

The clovers *Trifolium medium* and *T. pratense*.

In contrast, expected difficulties with spring-restricted species such as *Ophioglossum vulgatum* and *Narcissus pseudonarcissus* did not materialise. The drying remains of these species were suitably distinctive and conspicuous even by early July. Likewise *Colchicum autumnale*, although it did not occur in any quadrat, could readily be found on one site where it was known to occur.

4.2 The effects of management

CANOCO analysis

Testing the data by regarding sites as blocks showed that the effects of the key variables of grazing intensity, species and hay cut were significant at below $p<0.01$ but, as expected, produced distorted results. This is because such an analysis places excessive reliance on those few sites where a significant number of different treatments were present within a site. For instance, the generally very sparse *Filipendula vulgaris* appeared to be an important species connected with grazing intensity because it was present in one field out of two (the less heavily grazed one) on a single horse-grazed site.

As outlined in the Methods section above, this very conservative analysis is unlikely to be the best because it discards a great deal of useful information with the potential bias. It does however show that, even in the worst case, the data set is sufficient and powerful enough to detect the effects of horse grazing, intensity and other management variables.

The "best practice" analysis removed the effects of those variables suspected to be associated with bias (northing, easting and altitude) as covariables, and tested the rest in turn to build a model stepwise in which every variable included had an effect significant at at least the $p=0.01$ level. In the final model, the effect of grassland area was also removed as a covariable because, although species-area effects are interesting in their own right, they also may bias our interpretation of variables more amenable to positive management.

The results of this analysis are shown in Figures 5 and 6, which are plotted on the first two canonical axes of DCCA analyses. Other axes had little explanatory power and are not shown.

Figure 5 shows the effect of the environmental variables superimposed on dots representing the main species involved. Axis 1 (the most important) essentially contrasts intensively grazed sites with short swards against lightly grazed sites with tall swards which tend to be cut for hay. The effect of grazing with horses as opposed to cattle is similar to that of heavy grazing but a great deal weaker. The second axis highlights features of the vegetation sampled which were rarer in the data set, contrasting those few areas where litter had accumulated and stayed from the previous year and/or had a summer rest with those cut for hay and/or had had the same management for a long time.

The amount of bare ground present, vegetation height range and presence of a horse latrine had no significant independent effect and are not included in the model.

Figure 6 shows the main species associated with each management type. Not all species are labelled there because they are too close together. The effects are clear. Heavy grazing is associated with swards with abundant *Trifolium repens*, *Lolium perenne* and *Luzula campestris*. In the most extreme conditions, *Agrostis stolonifera* invades. Taller, hay cut swards have abundant *Lathyrus pratensis*, *Conopodium majus* and in the extreme *Heracleum sphondylium* and *Arrhenatherum elatius*.

Except for *Lathyrus*, the main subcommunity determinants are not heavily loaded. This confirms the suggestion in the NVC that the *Lathyrus* subcommunity is a "management" subcommunity while the others are driven by soil conditions.

Initial inspection of this analysis therefore suggests that good management for MG5 involves moderate grazing by **either** cattle or horses. Putting the grassland up for hay will produce a slightly different, but nevertheless valuable community. Over- or undergrazing will both cause damage. These initial impressions are explored below, first by examining the amount of effect that management has on sward height and its small-scale range, then by the effects on species categories of interest.

Sward structure

This study has examined sward structure at one time of year alone: the time of high growth rate in early and midsummer when either the sward is being left for hay or grazing animals are present but least likely to be keeping pace with sward growth. We estimated the combined height/density average given by a dropped disc and its range within a quadrat. Moreover, management categories reflected operations carried out over the few years previous to the study, not necessarily the same as those in 1995.

Despite these cautions, the results broadly match expectations. In theory, horses should produce an evenly grazed short sward (outside latrine areas) while cattle should at similar pressures produce a more patchily grazed sward. Figures 7 and 8 show that heavily grazed swards were both shorter and less variable in height in horse pastures than in the single heavy-grazed cattle pasture. Cutting for hay had a much lesser effect: the apparent effects under grazing are because some such swards had stock on when sampled while none of the ones put up for hay did.

Levels of difference shown by CANOCO

The contrast identified by CANOCO between the short heavily grazed swards with no hay cut and taller swards often cut for hay reveals very strong differences in the key species involved. Judged from the combinations of their axis scores, the ten species most associated with heavily grazed short swards were *Agrostis stolonifera, Bellis perennis, Carex hirta, Euphrasia agg., Hieracium pilosella, Hypochaeris radicata, Leontodon autumnalis, Lolium perenne, Ranunculus repens and Trifolium repens*. Many of these are usually sparse in MG5, so they can be regarded as "damage indicators" for swards which have been too heavily grazed.

These species are virtually absent from lightly grazed swards, although more abundant under horse grazing (Figure 9 top graph). Only the heaviest cattle grazing promotes them to near the maximum values found, at two to three times the frequency that they occur in even horse grazed swards at light intensity.

The effect of a hay cut appears to be to moderate this "damage" at medium grazing intensity (Figure 9 middle graph). No sites had heavy grazing and a hay cut so we cannot tell if putting up a field for hay could reduce the effects of heavy grazing. Putting up for hay has more of an effect on cattle grazed than on horse grazed sites (Figure 9 bottom graph).

In contrast to the ten most important "short" species, only one of the ten most characteristic "tall" species (*Arrhenatherum elatius*) could be regarded as a "damage warning", although a second (*Dactylis glomerata*) is also a coarse grass which can become over-dominant in some circumstances. The remaining eight are *Conopodium majus, Dactylorhiza fuchsii, Festuca pratensis, Heracleum sphondylium, Lathyrus pratensis, Primula veris, Ranunculus acris* and *Trisetum flavescens*. All of these are characteristic of at least some MG5 swards, although they can also persist in species-poor swards dominated by coarse grasses.

Like the "short" species, CANOCO reveals major differences in the "tall" species between treatments. The results (figure 10) are virtually the mirror image of those for the "short" species, with the notable difference that they are virtually eliminated, not merely reduced, in their worst conditions in heavy grazed swards. Hay cutting again moderates the effects of grazing, perhaps merely by limiting the grazing period when growth is slow.

Effect on measures of grassland "quality"

The above shows that there are strong differences between swards grazed at different intensity and to a lesser extent by different livestock species and whether or not a hay cut is taken. Such differences may however only reflect real damage if grassland attributes associated with the "quality" of unimproved swards are affected.

High-quality MG5 swards might be expected to have high species richness, many indicator species of unimproved mesotrophic grassland, many species thought to be otherwise in decline, and many species thought to be restricted to species-rich swards. Of these attributes, species richness is a simple derivative of the data: the other categories are derived from data supplied by English Nature and/or derived from Grime *et al* (1988).

Overall diversity (as measured by species richness) is similar across all grasslands except for heavily grazed ones, irrespective of hay treatment or grazing species (Figure 11). Heavy grazing, whether by horses or at the one site heavily grazed by cattle, results in a reduction from an average of approximately 25 species per square metre to 17-18 - a major difference. If anything, horses produce swards slightly richer in species than do cattle.

Indicator species abundance shows striking differences (Figures 12 and 13). The patterns are similar when the number of indicator species is examined (Figure 12) to those if both the abundance of the species and the strength of their association with unimproved grassland (indicator score) are taken into account (Figure 13). The differences are considerable, varying from only three indicator species per square metre in the field heavily grazed by cattle to 9-10 in lightly grazed swards irrespective of their other treatments.

On this aspect of grassland quality, the lighter the grazing is the better. It is better to take a hay cut as well, but the grazing species matters little. If anything horse grazing produces slightly better results in terms of biodiversity than cattle grazing.

Species-rich associates (after Grime *et al* 1988) are affected in a similar manner (Figure 14). Again, grazing intensity has the strongest effect, with such species being virtually absent from the field heavily grazed by cattle. Horse grazing generally produces a more species-rich associates and a hay cut is also beneficial. Taking hay from horse-grazed swards doubles the total frequency of these species but has a lesser effect on cattle grazed swards.

By contrast, species generally associated with the least diverse swards show no clear patterns (Figure 15). This suggests that such species, in MG5 grasslands, are associated with species-poor swards because they are the few which can survive there, not because they are promoted by conditions which result in impoverishment.

Grime *et al*'s "declining species" show weaker patterns (Figure 16). Only the heaviest grazing appears to affect them, causing a decline of approximately 25-30% in their frequency.

Life-history attributes associated with management

Management effects were tested against a wide range of the attributes considered by Grime *et al.* Strong and consistent results were obtained with only two sets of attributes: seedbank types and the established strategies of plants.

Classification of seedbank types passes from type 1 with no persistent seedbank through types 2 (seasonal seedbank only) and 3 (small persistent seedbank) to type 4, containing species whose regenerative strategy depends on a strong persistent soil seedbank. Figures 17 to 20 show a grade in response to management which follows the seedbank types. In essence, grazing species has only weak effects, but grazing intensity and hay cut are strongly associated with seedbank types. Cutting hay strongly favours species with no seed bank or with little persistence, and discourages those with a persistent seedbank. Conversely, species with a persistent seedbank are favoured by heavy grazing and vice versa. These results are generally in line with the species constancies in mesotrophic and other grassland communities reported in the National Vegetation Classification (Rodwell 1992 ed.). The grazing results are also similar to patterns reported by Gibson and Brown (1991) in calcicolous grasslands.

Established strategy is to some extent correlated with regenerative strategy, so the strong differential effects on competitors, ruderals and stress-tolerators is not surprising (Figures 21 to 23). Little effect was seen on species with mixed strategies.

Competitors are generally sparse in MG5 grasslands and are virtually eliminated by heavy grazing and favoured by cattle, as opposed to horse, grazing. They are also favoured by a hay cut (Figure 21).

Ruderals are also sparse, but clearly rarer in lightly grazed conditions, irrespective of grazing species or hay cut (Figure 22).

More of the species characteristic of unimproved grasslands are stress-tolerators (Figure 23). Grazing species has little effect, although there are slightly more stress-tolerators in horse grazed swards. Hay cutting has little consistent effect. Grazing intensity again has the strongest effect with, perhaps against the obvious prediction, heavier grazing tending to produce fewer stress tolerators.

Latrines

One of the most conspicuous effects of heavy horse grazing is to produce a mosaic of tall latrine areas with very short closely grazed turf. Such latrine areas have been cited as a manifestation of horse damage. In this study, a number of latrine areas were noticed, but only in one case was there an obvious latrine area in a mosaic of recognisable MG5 grassland. In other large latrine areas, the surrounding grassland was not MG5. More will be said about this aspect in the Discussion below.

In this single case where the direct effect of a latrine area could be tested, the sward was clearly "damaged". Table 6 shows a comparison of the two areas, including all species which reached an average of at least one cell occupied per square metre in either type. Data are shown both as average cell counts (out of 25) and constancy across the five quadrats taken in the latrine area (I to V).

Bearing in mind that the heavy grazed area was already "damaged" according to the criteria examined above, the latrine area caused a further reduction of eight species per square metre, from 23 to 15 species.

At least thirteen of the commoner species in the heavy grazed area were severely reduced in the latrine area. Only two species increased in the latrine area. Adversely affected species included MG5 species such as *Cynosurus cristatus, Hypochaeris radicata, Leontodon autumnalis, Lotus corniculatus*, and *Luzula campestris*. Also some of the "heavy grazed" and weed species were eliminated: *Bellis perennis, Poa annua* and *Senecio jacobaea*.

The two increasing species are the grass *Poa pratensis*, usually sparse in MG5 and the MG5 constant *Centaurea nigra*. Indeed these two species conspicuously marked the latrine area, especially *C.nigra* with its robust growth there in contrast to the small rosettes surviving in the heavily grazed area.

In conclusion, horse latrine areas can indeed severely damage a MG5 sward even when the surrounding grassland is still a recognisable MG5 with many of the characteristic species.

Table 6: Penorchard Farm - comparison of latrine and other areas

Species	No latrine	Latrine
Agrostis capillaris	22(V)	22
Anthoxanthum odoratum	23(V)	25(V)
Bellis perennis	13(IV)	2(I)
Centaurea nigra	6(V)	18(V)
Cerastium fontanum	0.6(III)	4(V)
Cynosurus cristatus	25(V)	15(V)
Festuca rubra	25(V)	24(V)
Holcus lanatus	22(V)	25(V)
Hypochaeris radicata	13(V)	
Leontodon autumnalis	5(V)	
Lolium perenne	9(V)	6(V)
Lotus corniculatus	7(IV)	
Luzula campestris	12(V)	
Plantago lanceolata	15(V)	8(V)
Poa annua	5(IV)	
Poa pratensis	0.6(I)	16(V)
Potentilla erecta	8(II)	0.2(I)
Prunella vulgaris	10(IV)	2(II)
Ranunculus acris		2(III)
Ranunculus repens	13(V)	18(V)
Rumex acetosa	4(IV)	2(IV)
Senecio jacobaea	6(V)	0.6(I)
Taraxacum agg.	7(V)	0.8(II)
Trifolium pratense	2(III)	0.2(I)
Trifolium repens	21(V)	13(V)
Species per square metre	23	15

The effects of abandonment

Opposite to the effect of overgrazing and latrine areas, but equally damaging, is the effect of abandonment. In this study, the most directly comparable site was a field adjacent to the latrine area at Penorchard, but not completely comparable because the abundance of species such as *Briza media* and *Leontodon hispidus* was unusual for the site.

This field had not been grazed or cut for at least three years prior to 1995. There was a massive build-up of litter from previous years, associated with an average of only 14 species per square metre. The grass mixture was anomalous, being dominated by mats of *Holcus lanatus* with *Cynosurus cristatus* being notably scarce. Other MG5 constant grasses were still frequent. The greatest reduction was in herb diversity, with only *Leontodon hispidus*, *Centaurea nigra* and *Plantago lanceolata* being frequent in all quadrats. Typically, most quadrats had one or two of the other MG5 herbs frequent, differing from quadrat to quadrat, and all others sparse or absent. The orchid *Dactylorhiza fuchsii* and the fern *Ophioglossum vulgatum* were however present in more than one quadrat each.

Overall, this shows a similar amount of vegetation change under abandonment for a few years to that shown in the development of a horse latrine area. Clearly, this "damage" may differ in other aspects such as its reversibility.

5 Discussion - grasslands under different management

5.1 Horses and cattle

When all other factors are held equal, there is very little difference between the species composition of horse and cattle grazed MG5 grasslands. In some ways, horses are slightly beneficial, for instance to overall diversity and in the amount of indicator species in the vegetation. Horses also produce slightly fewer "competitor" species which may risk dominating the vegetation if management were relaxed for some reason.

The ability to estimate grazing intensity accurately may place a slight limit on these conclusions. If the estimates of grazing intensity are truly comparable between livestock species, then horses do allow a number of species (some of them "legitimate" MG5 species) to enter the sward which at high grazing intensities characterise a damaged, low-diversity sward. At low grazing intensities, these species appear to cause no harm and indeed increase sward diversity overall.

5.2 Grazing intensity

In contrast to species of grazing animal, grazing intensity has a major determining effect on species composition. Swards included in this study as heavily grazed are clearly overgrazed in that they have low diversity, fewer mesotrophic grassland indicator species, each of which is less abundant than under light grazing, fewer species associated with species-rich vegetation and fewer declining species. This catalogue of effects adds up to considerable damage to the grassland vegetation.

Further, species which are promoted by heavy grazing include those which, especially *Lolium perenne*, are characteristic of grasslands which have suffered some agricultural improvement. This emphasises the difficulty of separating cause of damage arising from overgrazing: the effects are likely to be both physical and associated with faster nutrient turnover and/or, where stock feeding takes place, inadvertent fertilisation. Whatever the cause or causes, the damage is clear.

Nevertheless, lack of management is equally harmful: it is possible to "undergraze" and a sward which had had no grazing or cutting recently had species richness lowered over the maximum by as much as the overgrazed swards. Unsurprisingly, species which persist under such conditions include "competitor" species which are often found dominating rank swards of very low diversity elsewhere.

5.3 Cutting for hay

This study shows clearly that cutting for hay produces a significantly different species composition within MG5 from that seen under pasture alone. The National Vegetation Classification has not recognised this as a separate hay meadow community (unlike for instance MG4) but the effects of hay cutting in this study appear to favour the *Lathyrus pratensis* subcommunity of MG5.

Here, hay cut swards were slightly more diverse and had more abundant indicator species. To a minor extent, putting up the grassland and cutting for hay may mitigate the effects of overgrazing. However, this effect is weak. Unfortunately, its power to reverse the effect of very heavy grazing cannot be tested because no fields classified as heavy grazed had a hay cut. This is either because such fields simply will not grow a worthwhile hay crop if put up, or it is necessary to graze for the whole growing season to produce the appearance of sward which was classified by English Nature as "heavy" grazed.

5.4 Other management activities

The other direct management operations examined here were giving a winter or summer rest and the length of time for which management had been known to be consistent. Although having significant effects, none were important on the main axis of change. Therefore they could not, for instance, be reliably used to try to mitigate the effects of overgrazing because they do not operate in the same way. Other management practices which might be attempted, such as dung removal, were not addressed by this study.

In contrast, their effect, with the exception of winter resting which was very weak, was concentrated on the second canonical axis of the DCCA ordination. Summer resting had by far the stronger effect, and was opposed to management time. The species associated with these effects are difficult to interpret. Summer resting favours a collection of species with little in common except that some are calcicoles (strongest associates *Genista tinctoria, Plantago media, Filipendula vulgaris, Ranunculus bulbosus*). Likewise an unusual collection of perennials was associated with long periods of consistent management, such as *Arrhenatherum elatius, Heracleum sphondylium, Conopodium majus* and *Vicia cracca*.

Here these associations are merely noted in case of their future usefulness. The main point is that management operations such as these will not easily undo the damage caused by overgrazing or lack of management.

5.5 Interactions between management types

This study bears out current recommendations and practice in that the most diverse MG5 swards of all are those which experience both a hay cut and light to moderate grazing of the aftermath. However, pasture swards are valuable in their own right. Provided that they are not grazed too heavily, they have only slightly fewer species overall and in the categories of interest favoured in aftermath-grazed hay meadows. They also have a distinctive composition which is, in the abundance of mesotrophic grassland species (such as *Carex hirta, Euphrasia* agg., *Hieracium pilosella, Hypochaeris radicata, Leontodon autumnalis*) of value in its own right.

Provided that the sward is not overgrazed, horses produce slightly better results if anything as measured by overall richness and categories such as indicators and declining species. The only management which might give slight cause for concern is that even moderate horse grazing may allow in some of the species which, when grazing is too heavy (such as *Agrostis stolonifera, Lolium perenne, Ranunculus repens, Trifolium repens*), come to dominate the sward to the exclusion of the others.

The remainder of this discussion critically examines the robustness of this conclusion and the generality or otherwise of its applicability.

5.6 Why do horses appear to be good grassland managers?

Types of horses

Oates (1994) noted the usefulness of "traditional" breeds of horses to manage heathlands, moorlands and grasslands. Many common and other lands have had such semi-feral breeds, either on their own or with mixed stock, grazing for centuries. He noted the ways in which such animals differ in their selectivity and behaviour from more thoroughly domesticated breeds. In this view, good conservation management can often use horses, but the traditional more hardy breeds of pony are best.

In this study no attempt was made to restrict or compare types of horses: there were not enough sites available to do so. However, "horses" used to graze sites varied from ponies including stock similar to the semi-feral breeds through the whole spectrum to thoroughbred horses.

The beneficial results seen from horse grazing in this study are thus in spite of the inclusion of breeds which, in other vegetation than lowland grasslands, might be thought to be inadequate for conservation management.

The way people use horses in grassland

Often, horse owners at most times of year do not want the animals to be in tall lush swards because of the risk of disease (Oates 1994). If the animals run short of fodder, it is possible to feed them in the field where they are. Feeding may cause further damage through trampling and eutrophication. Further, the horses are frequently not just in a field to graze: they are also in the open air for exercise.

Although this study cannot provide further quantitative evidence for these patterns, because samples were strictly restricted to MG5 swards, there were abundant examples where poached areas near gates, stock feeding areas, horse jumps and paths used for riding through fields were excluded from the vegetation used for study because they did not support MG5 vegetation. In such cases, there was every reason to suppose that, in the absence of such disturbance, these areas would have supported MG5 grassland like the areas surrounding them.

In a time when the draught ox in Britain is a beast of the remote past, cattle are always in a field to graze and to gain benefit from the food. This is the sole purpose of them being there, whether the farmer is organic or industrial and whether the cattle are there for growing beef or milk. In order to succeed, the cattle must be gaining the greatest possible benefit from the sward, ie grazing at an intensity which maximises sward productivity and forage intake. In cases where the farmer fails in this and too many cattle are left in, or for too long, then the damage caused by heavy cattle grazing can be as bad as the damage caused by heavy horse grazing.

The interests of the horse grazier and cattle grazier in unimproved grassland are thus often opposed. The cattle grazier's interests often coincide with those of the nature manager: the consequences of overgrazing are often less, or take longer to become apparent, to the horse grazier.

Grassland management in sites of high nature conservation value by horses will therefore need positive controls imposed through management agreements or other mechanisms to ensure that this does not happen.

Differences in grazing behaviour

Horses and cattle behave very differently when grazing. Interest in these differences has focused from two directions: interest in food selection behaviour (e.g. Gudmundsson and Dyrmundsson 1994, Archer 1973) and interest in vegetation types clearly associated with different species of grazing animal (e.g. Putman *et al* 1987, 1991). Such studies have produced a classic understanding of features including the "pony lawns" of the New Forest and the contrast between short turf and tall latrine areas.

Horses are well-known for leaving conspicuous plants such as ragworts (*Senecio jacobaea, S.erucifolius*) docks (*Rumex* spp.) and black mullein (*Verbascum nigrum*). A corollary of the last is that horses leave more flowers (and hence seeds) than cattle. This can be detrimental, especially if ragwort (usually avoided by both horses and cattle) later wilts and is then eaten, or simply sets more seed than if grazed off when small. The avoidance of flowering material can also be beneficial, such as in allowing desirable plants to set seed or, with for example black mullein, rare invertebrates to survive which disappear under cattle grazing (Bioscan 1995).

Other studies on horse latrine areas in semi-natural grassland in Britain have involved areas where mixed stock are present. In the New Forest, none of the species favoured in latrine areas agree with those in this study, being restricted to coarse short-lived or weedy species such as *Senecio jacobaea.* However, the New Forest latrine mosaic is partly broken in late winter by the combined action of cattle and ponies (Putman 1986). This alternation of heavy grazing pressure (allowing gaps to form for germination) and its relaxation in summer (allowing coarse species to grow tall and seed) is in contrast to our study where the single species of grazing animal is unlikely to open the mosaic in winter. Nevertheless, even in the New Forest, the mosaic is never broken enough to stop tall latrine areas re-forming in the following year (Putman *et al* 1987, Ekins pers. comm.).

Putman *et al*'s (1991) studies included grasslands similar to MG5 on Port Meadow and Staines Moor, but again the grazing species were mixed. In common with this study, *Plantago lanceolata* and *Trifolium pratense* were commoner away from latrine areas, but their latrines on Staines Moor favoured a range of species which had little in common with those in our study, and also differed from the New Forest latrines.

In conclusion, latrine areas with mixed stock species are likely to be of only limited use in predicting the way in which the large patches associated with horses grazing alone develop.

This study also supports the opinion that most of these phenomena are only expressed to the full under heavy horse grazing. On MG5 grassland in Worcestershire, large latrine areas were only apparent in very heavily grazed fields. Under lighter grazing, such areas were not conspicuous. This may be because the overall grazing pressure is light enough for horses to return where they have dunged after a season or more and still make little or no visible difference to the sward.

Does horse damage just take a long time to become apparent?

It might still be that light or moderate horse grazing damages swards, but only after many years. However, this study has included grasslands in good condition known to have been grazed by horses for several decades, and the period for which management had been fixed was neither associated with correlates of sward damage, nor with grazing species or intensity.

It is likely therefore that, if there were detrimental effects of light or moderate horse grazing expressed in the long term, this study would have detected them. We found none.

The damage associated with heavy grazing may, in contrast, increase over time. This would be expected if nutrient turnover increase and/or fertilisation were important mechanisms in generating the observed damage. In most cases where previous data were available for fields studied here, the species found were in broad agreement (except where clearly different NVC communities had been sampled), and the range of species richness observed was highly similar in both this study and previous data.

In particular cases, all involving heavy grazing by horses, there was a marked difference. This was most obvious at Berry Mound Pastures, where several fields were marked as MG5 grasslands on site cards held by English Nature. Previous quadrat data from the same areas concurred with this, but the fields in question, which had been heavily horse grazed the whole time, were so dominated by *Lolium perenne* as to be clearly MG6. In one case, a large horse latrine was observed in this study and accordingly quadrat series were prepared because the field was marked as MG5 on the site cards. In recording however it quickly became apparent that the short phase in the field was now species-poor MG6 grassland and the quadrat series was abandoned.

The above is circumstantial evidence, because not enough previously recorded quadrats were available to test it. It suggests however that the damage which initially becomes manifest as a slightly impoverished MG5 lawn alternating with a heavily impoverished tall latrine area, may eventually become a species-poor short MG6 grassland alternating with species-poor tall grassland in the latrine areas. By this time the grassland is so damaged that it is unrecognisable as its original community.

5.7 Conclusion - consequences for management

In conclusion, there is little wrong with replacing cattle with horses in the management of lowland MG5 grassland, provided that they are managed in the same way.

Because of intrinsic pressures to graze horses too heavily, horse grazing will often be more difficult to control properly and will need well-drafted agreements and continued supervision. Clearly, proper control is needed in any management agreement, but the pressures arising from horses differ in nature from those associated with other stock.

The richest MG5 grasslands are those which combine a hay cut with aftermath grazing, but pure pastures are distinctive and valuable in their own right. If the traditional management of a field is known, it should be kept up rather than succumb to the temptation to switch from pasture to hay for the sake of a small increase in diversity.

Grasslands which have been grazed heavily by horses may not have irretrievably lost a significant portion of their value. This study cannot tell if any damage can be reversed easily or not - only experimental trials with repeated monitoring could answer this question. However, the initial test should be to see if the short turf is still recognisable as MG5. If it is, even if there is an impoverished latrine area present, the short grassland outside latrines is likely to retain much of its value. This test needs care in its application: in such areas well over 20 species per square metre are typically present but to detect them under heavy grazing every fragment must be examined.

Should there be doubt, and control over grazing is possible, then grazing pressure should be relaxed and the sward re-examined in the subsequent year and/or later.

This study does show that other management practices are not sufficient to counter the effects of continuous heavy grazing. Continuous heavy grazing pressure cannot be mitigated by putting up a field for hay or resting the sward during one season - there is no substitute for reducing the grazing pressure to an acceptable level. The stock feeding and poaching often associated with heavy grazing have even worse effects: in these cases the resulting grassland is no longer recognisable as a species-rich unimproved community type.

Despite the above, removing all management by grazing or cutting is just as damaging, and almost as quick in its effects, as overgrazing.