8. Effects of farmyard manure on nature conservation interests

8.1 Nutrient effects and communities

8.1.1 "Study of the causal factors determining the distribution of plants and vegetation is a prime objective of ecology" (Gittins 1968). He showed how soil P and K influenced species distribution, and how these and other attributes influence grass yield. In the same volume (Bradshaw 1968), wrote "some of the best evidence for the importance of soil nutrient status as a factor determining plant distribution is to be got from the fertiliser usage of the agriculturalist on grassland, both natural and sown" and he quoted Davies (1960) saying "there are very few grasslands in which soil nutrients are not limiting". Therefore the addition of FYM to grassland must influence its botanical content (section 5) and hence its nature conservation value. The extent of influence depends on the initial fertility, the grassland management, the botanical content, the management of FYM production, storage, the evenness of spread, and the rates and periodicity of application. The effect is consequently widely variable, from the maintenance of the current species richness and diversity through to undetectable, insignificant or random seasonal changes on to a complete and deleterious transformation of the grassland. We obviously seek to maintain the existing nature conservation value, at least, to minimise the effect and speed of change.

8.1.2 Dodd *et al* 1994 ascribed botanical data from the Park Grass Experiment plots to National Vegetation Classification (NVC) communities and sub-communities (see Rodwell 1992) using the computer programme MATCH. This programme compares botanical field data with the profile of the plant communities described by the NVC using a similarity coefficient. Dodd *et al* 1994 listed, for each treatment plot and time period, the three NVC communities and sub-communities which had the highest similarity coefficients and thus most closely matched to the published NVC community descriptions.

The unlimed and limed Park Grass plots receiving FYM were regularly matched with the semi-natural neutral grassland communities MG3 and MG5 (see Glossary). This would initially suggest that the FYM treatment is consistent with the maintenance of species-rich meadow communities of high nature conservation value. However, regular matching of these plots with the MG3a sub-community (the more species-poor, grass dominated sub-community of MG3) and occasionally with the semi-improved species-poor MG6 and MG7 (although at lower coefficient values) communities and the relatively species-poor *Arrhenatherum elatius* dominated MG1e does suggest that the FYM application rate of 35 t ha^{-1} every fourth year may be sub-optimal for the maintenance of the nature conservation value of semi-natural meadows.

It is interesting to note that this rate is higher than the rate (20 t ha^{-1} every 3-5 years) prescribed by Jefferson (1994) in Crofts & Jefferson.

8.1.3 Meadows represent ecosystems and fertilisers influence all the components (Rabotnov 1977). Rabotnov has published the most comprehensive review of the influence of fertilisers on the plant communities of mesophytic grasslands. He states that the competitive ability of species is determined by their ability:

a. to absorb nutrients;

b. to utilise the absorbed nutrients effectively;

c. to grow successfully in the swards with a changed microclimate, especially with decreased light intensity.

There is not space here to do more than briefly summarise his work so it is recommended as excellent reading for those interested in this topic. Similarly there has been more recent work on the influence of inorganic fertilisers on trial plots in semi-natural meadows, for example in the Tadham Moor Project on the Somerset Levels, which are briefly reviewed below in Section 8.1.4-8.1.7.

8.1.4 Briefly, Rabotnov (1977) states that not only do fertilisers affect the growth of meadow plants above ground but also affects:

- ❑ the ability of plants to produce seed;
- ❑ plant responses to heat;
- ❑ the winter hardiness of plants;
- ❑ the mass of underground storage organs;
- ❑ the number of micro-organisms in the soil, and their decomposition;
- ❑ the relationships between herbaceous plants and their symbiotic and parasitic consorts including nodule bacteria and mycorrhiza;
- ❑ plant-soil water relations.
- ❑ the water percolating capacity of the soil and water holding capacity, due to invertebrate activity and root growth and plant responses to soil aeration and;
- ❑ the competition between species.

Responses depend on the time and form of fertilisation, the presence or absence of species able to take advantage of the added fertiliser, and meadow use or harvest date, as well as different characteristics of biotopes (ie environmental regions with their characteristic vegetation).

8.1.5 The Tadham Moor Project was initiated in 1985/6. Its aims were to establish:

a. if there is a 'safe' limit to the amount of fertiliser that could be applied to species-rich hay meadows of the Somerset Levels which would allow their floristic diversity to be maintained;

b. the agricultural output achievable within such a safe limit;

c. the agricultural output foregone by adhering to a 'safe' fertiliser input;

and upon the cessation of fertiliser use to establish:

d. the speed and direction of botanical change;

e. impact of disturbance, gap creation, and reintroducing seed of lost species on speed and direction of botanical change;

f. impact of changing the cutting date on botanical recovery.

Extra funding was also provided to quantify the losses of soil nitrogen following different levels of fertiliser application (Tallowin *et al* 1994).

8.1.6 The species richness of the hay meadows was significantly reduced by even the lowest fertiliser input of 25 kg N per ha per annum, within six years suggesting that there is no 'safe' amount of (*inorganic*) fertiliser nitrogen that can be applied to these meadows. Fertiliser inputs particularly of phosphorus caused increased dominance of grasses and a reduction in the abundance of most of the distinctive wet hay meadow species. Under high fertiliser input the species-rich wet hay meadow communities were replaced by species-poor plant community types. (Tallowin & Smith 1994; Tallowin *et al* 1994). The word '*inorganic*' above is added by this report's authors given that it was the form of fertiliser used and the researchers included it in all titles relating to this work.

8.1.7 Once damaged by (inorganic) fertiliser use these meadows did not readiliy recover when inputs ceased and the traditional management resumed. An estimate was made of the time required for the vegetation to recover to its pre-treatment condition (reversion time). Tentative estimates of reversion times for the treatments are : N25 : two years, N50 : four years, N100 : seven years (Mountford *et al* 1994; Tallowin *et al* 1994).

8.1.8 The calculated agricultural output foregone by adhering to a 'safe' fertiliser input of zero compared to a relatively intensive agricultural input of 200 kg N ha^{-1} plus adequate P and K was £90 ha^{-1} for beef and hay farms with £272 ha^{-1} for dairy farms (Tallowin *et al* 1994). Intermediate fertiliser inputs between these levels was not quoted, and given the steep rise in output possible with relatively small inorganic fertiliser inputs a linear extrapolation of income change with fertiliser input is not reasonable. However, these results indicated that ESA payments would have been adequate to compensate farmers for production foregone by adhering to the ESA guidelines. The other results of this project showed the over-riding need to reduce soil nutrient status to allow non-grass species to colonise gaps and that changes in cutting date over two years had no significant effect. To avoid N leaching in Tadham Moor annual inorganic fertiliser N needed to be less than 100 kg ha^{-1} (Tallowin *et al* 1994). Whilst these results indicate to the reader the deleterious effect of inorganic fertilisers on species richness and the economic benefits to farmers of using such fertilisers outside an ESA; it is hoped that the reader will understand that a readily available, quickly released inorganic fertiliser is quite different from FYM both in its constitution, constituents and therefore its consequent effects. Almost certainly the reason is the presence of the organic matter in FYM, (which determines the C:N ratio according to its state of decomposition at the time of application), given all other things being equal. The C:N ratio determines the speed of N release, ie the lower the ratio the faster N is released. Therefore, as well as the upper C:N ratio limit of 18, suggested in Section 7.4.7 to prevent inadequately composted maures being applied to semi-natural hay meadows; it may also be suggested that a minimum C:N ratio of 12.5 is taken from Section 6.2.4 with a target ratio of 15. However, these figures would only be valid for representative samples taken , transported and kept under standard (and yet to be defined) conditions - another suggested topic for research.

8.2 The overall effects of FYM

8.2.1 The effects of FYM are both direct and indirect:

a. FYM adds and alters the balance of soil nutrients and consequently uptake by plants; nutrients can alter both the dominance of plants and species composition (Carson & Pickett 1990, quoting others) as well as increasing plant biomass.

b. FYM increases the soil organic matter/humus; possibly for the better (in terms of sulphur supply derived from protein, trace element supply, buffering the effects of soil pH and feeding the soil microbial biomass).

c. FYM can increase soil water holding capacity.

d. There is some evidence that organic manures may increase the Co_2 concentration in a plant's microclimate which could promote plant growth in addition to the supply of N, P & K. It is assumed (but not tested) that the effect on growth is insignificant.

e. FYM can smother some herbage, creating germination niches or reduction possibly to extinction of some plant populations.

f. FYM handling can create gaps in a sward by the passage of machinery even when not actually spreading but when transporting or handling material.

g. FYM can add weed seeds, and pathogens to a meadow- the extent depending on the type and degree of composting.

h. FYM usually increases and changes the invertebrate species found in grassland above and below ground, which in turn tends to increasese the numbers and alter the behaviour of predators. However, if ammonia concentration is high, as in slurry, a negative effect on springtails (*Collembola* species) and mite (*Acari* species) has been noted (Marshall 1977; Curry *et al* 1980; Curry 1994). Dung on the surface provides an important, if transitory, habitat and food source for invertebrates and invertebrate activity makes an important contribution to dung decomposition by accelerating conversion of dung into humus complementing the slower but essential fungal and bacterial humifiers (Skidmore 1991; Curry 1994). This means that sufficient time must elapse for degradation of the active ingredient and composting where cattle have been treated with Ivermectin (a persistent parasiticide with activity against a range of organisms, some of which are involved in degradation of manure). The composition of the dung community varies considerably depending on the age (of the dung/manure), location, climatic and other environmental conditions (Doube 1987 quoted in Curry 1994). For a list of the species of British insects associated with the **dung** (not FYM) of ungulates (cattle, sheep, deer and horses) see Skidmore (1991). Skidmore cautions that the fauna of manure is very different from cow dung, even when the manure consists mainly of cow-dung. Certain species (eg the lesser earwig *Labia minor*; biting housefly *Stomoxys calcitrans*; and common housefly *Musca domestica*) are indicative of the higher temperatures of a manure heap.

i. FYM applications can cause run-off and leaching causing pollution and loss of nutrients, depending on the slope, soil type, time of application and subsequent weather. Nutrients and the bacteria from FYM can cause biological and chemical oxygen demand, and eutrophication altering the balance of organisms away from the site of spreading.

j. FYM affects the time, investment and energy use of a farmer or land manger so having economic costs associated with it as well as offering economic savings.

k. FYM can change atmospheric conditions in terms of ammonia and nitrous dioxide emissions, as well as possibly causing a public nuisance - the extent of which depends on the type and degree of composting and the method of application.

8.2.2 Much of the above indicates what a potent force for change FYM can be. So it commands attention to be paid to it. Just as there is the potential for adverse affects, so there is potential for good. One can have too much of a good thing but to use another cliché 'too little, too late' isn't much good, either. So we attempt to achieve a balance.

8.2.3 Mitchley (1993) wrote that "grazing, mowing... and nutrient applications, have major impacts on vegetation structure and hence diversity of plants and animals in grassland." He quoted Bobbink (1991) although Bobbink was not the first to observe that applications of nitrogen increase the grass component and tend to produce a tall dense structure.

8.2.4 Lawes & Gilbert (1859, page 268) wrote "farmyard manure ..increased the actual amount and proportion of total Graminaceous herbage"..and indicated a change in the proportions of different grass species.

8.2.5 Many writers have observed that the general effect of fertiliser applications is to reduce species diversity of plants (Marrs 1993 offers a good summary but also see Mitchley 1993 and Tallowin *et al* 1994) although Tilman & Pacala (1993, page 22) suggest that this is due to light limitation rather than as a direct result of resource addition. Allied to this, researchers have demonstrated close negative relationships between biomass productivity (hay yield) (and hence fertility) and species denisty (Silvertown 1980, Oomes 1992, Smith 1994).

8.2.6 Many writers claim that treatments which result in reduced soil nutrient levels can be expected to result in increased biotic diversity (Marrs 1993; Mitchley 1993: Tallowin *et al* 1994) and disturbance can create gaps in plant communities, providing space for establishment (Carson & Pickett 1990 quoting others).

8.2.7 However, these observations may be an over-simplification. Grime (1979) suggested a 'hump-back model'; suggesting that species diversity is maximal at an intermediate environmental stress level and at an intermediate level of intensity of management which one may interpret as being between a nutrient-rich and a nutrient-impoverished status. (One can also include calcium as a 'nutrient' which largely determines pH and this has a large effect on determining the availability of other nutrients). This 'happy medium' on a fertility scale will not be the same for all species; but the authors suggest that at a site where desirable species are present in desirable numbers due to site situation and past management then the hump-back model may provide a useful analogy, and similarly if change is desired or proposed it could be used. More recently Huston & DeAngelis (1994) offered an explanation for the commonly observed 'hump-shaped' relationship between community productivity and species richness.

According to their analysis (quoted in Grace 1995) "in very unproductive communities (species) richness is limited by conditions that exceed the tolerances of most species, resulting in few species. As soil resources increase, they postulate that there will be increasing species richness because of decreasing (nutrient) depletion zones in the soil providing that competition is primarily below ground. Once biomass is sufficient for above-ground competition for a resource (eg light) to predominate their model predicts that diversity will drop off rapidly; thus their model is able to generate a hump-shaped curve for the relationship between site productivity and species richness.

Others have found the hump-back model less useful as a predictive tool when looking at a limited range of habitats or communities such as neutral meadows (Roger Smith (pers. comm.) who quotes Marrs 1993 and Smith 1994). Smith (pers. comm.) found a linear relationship between species density and nutrient levels in mesotropic grasslands but with much variability in the data suggesting other factors were also important influences. Few studies have elucidated cause and effect (Gibson 1988); but with the Huston and DeAngelis (1994) paper and consideration of Grover (1995) this is changing.

8.2.8 Mowing and removing of cuttings, as in hay-making, can be regarded as a means of reducing soil nutrient levels so increasing species diversity by removing tissue from potentially dominant species (Crawley 1983 and Bakker 1989) so offering a counter-acting influence to FYM on the flora of the hay-meadows relevant to this study.

9. Current Practice on Certain Unimproved Hay Meadow SSSIs as found by a Survey of English Nature Local Teams

9.1 An outline of the methodology employed in the questionnaire survey

9.1.1 Survey questionnaire forms were determined by the authors. The forms were then sent to English Nature Local Teams in August 1994, with the request that a form be completed for each hay meadow that had received FYM since 1 September 1986. The questionnaire form used is provided at Appendix 6.

9.1.2 Completed forms were received from 10 EN staff relating to 11 meadows, as listed in Section 9.2. Comments were received from another member of English Nature regarding three more meadows; but details were sketchy. (Tim Barfield, pers comm).

The main conclusions of the survey were:

1. Records on FYM inputs are incomplete.

2. Practice is extremely variable both over time and between locations.

3. Conclusions by site managers about the effects of FYM tend to be general and subjective. They have not been verified by the authors, merely reported here.

9.1.3 **Additional Comments**

There were indications that more information existed; but unfortunately this was not supplied. There were also indications that, more often than not, the requested information was lacking and from this it is suggested that pro-forma or check lists are drawn up to standardise the collection of information from future site visits by English Nature staff. This could assist English Nature staff, when attempting to draw conclusions from current practice and assist other researchers who wish to pursue lines of enquiry relating to SSSI's or NNR's. Additional interpretative comments could be added to such checklists, where appropriate.

9.1.4 **Lessons for the Future**

Information relating to quantities of FYM was contradictory in some individual responses and in others lacking. Cattle weights and numbers, housing system, straw input and housing period all need to be accurately recorded if accurate calculations of FYM production are to be made. Then accurate proportions of this total production need to be allocated to different areas to estimate application rates.

9.1.5 In the past generally insufficient information has been recorded concerning management, inputs and hay yields. Only for Arkle Beck, after considerable research, is there reliable data relating to hay yields, hay dry matters and bale weights. Lack of information gives scope for argument in negotiating management agreements, so independent checks are always advisable, although unsympathetic or disorganised farmers would still cause problems, and plans would need to be made to ensure that intentions were agreed and budgets prepared.

9.2 Survey of EN Local Teams

Respondents to a questionnaire survey of EN Local Teams regarding management of conservation grassland are listed in Table 17:

Table 17.

Respondents	Meadows
1. Ben Mercer	Arkle Beck, N Yorks
2. Russell Wright	Sutton Lane, Dorset
3. P.F. Ulf - Hansen and Pip Oxenburg	Whitevine Meadows, Somerset
4. Jeremy Fraser	Goldborough Farm Meadows, Dorset
5. Graham Taylor via Wesley Smyth	Barrowburn Meadows, Northumberland
6. Graham Taylor via Wesley Smyth	Barrow Meadows, Northumberland
7. Clare Trinder	Lee Farm Meadow, Derbs.
8. Clare Trinder	Bradwell Meadows, Derbs.
9. Dave Clayden	Snaper Farm Meadow, N Yorks
10. Tim Coleshaw	Mottey Meadows, Shropshire
11. Caroline Watt	Greenhaugh (The Bog)

In addition, comments on three more meadows were received from Tim Barfield relating to Seagrave Meadows, Bozeat Meadow and Plumpton Pasture (see 9.4).

9.3 Results of Survey

The information yielded by the survey is summarised in Tables 18 and 19:

9.4 Summary of comments from Tim Barfield

9.4.1 Tim Barfield (pers comm) expressed misgivings concerning the practice of using FYM on semi-natural meadows. However, the three sites he mentioned that have undergone deleterious changes and now consist of sem-improved grassland appear to have, in addition to the application of FYM (periodicity not given) received one or more of inorganic fertiliser applications, herbicide, poultry manure or very intensive grazing. Thus, it is not possible to factor out the impact of FYM and hence to draw conclusions.

Table 18. Summary of replies by English Nature Local Teams to a survey undertaken in 1994 for this report enquiring into current practice on conservation sites and their opinions

Note: There are lots of ? below which require checking.

Site Name:	Arkle Beck 1	Sutton Lane 2	Whitevine 3	Goldborough 4	Barrowburn 5	Barrow 6	Lee Farm 7
Soil	Organic Sandy Clay	Sandy silt gravel over clay	Clay	Clay	Sandy	Sandy silt Riverside gravel	Loess sand over Limestone
NVC	Mix of MG 3 & MG 8	MG 5b	MG 5b	MG5a/c	?	?	MG5
Drainage	Occasionally floods	Wet in places	Moderate	Poor	Good	Good	Good
Inorganic N	60-100 u/ac 10 yrs ago	-	None in last 8 yrs		-	N 10 u/ac/yr	No
P	30-50 u/ac 10 yrs ago					P 5 u/ac/yr	
K	30-50 u/ac 10 yrs ago					K 5 u/ac/yr	
Lime:	? t/ac in 1986/7	? t/ac Calcified Seaweed in 1986	None	-	-	None?	
FYM applied	Yes - see below	Yes - see below	Yes	Yes	Not since 1975	Yes once in 26 yrs	Yes
Hay cut	Mid-July	After mid-July	7 July- 15 Aug	July/Aug	24 July- 3 Aug	Not known	Late Aug usually but Sept 1 year in 5
Hay yield	1.82t/ac Fresh (4.5t/ha)	1.25t/ac (3.1 t/ha)	1.27- 1.6t/ac (3.1 - 4.0t/ha)	2.3t/ac (5.7t/ha)	0.5-0.85t/ac (1.3-2.1t/ha)	1.1 - 1.3t/ac (2.8 - 3.2t/ha)	Half of quoted figure of 2.7 t/ac (6.66T/ha)?
Grazing	50 Sheep graze from 20 Mar - 10 May and from 15 Nov - 15 Dec on 15.56 ac (= 6.3 ha)		100 Sheep graze mainly in September on 12.6 ac (= 5 ha)	-	Sheep Aug- mid-May at various times unknown nos.	Not known	Shut up for hay 8 weeks before cutting
	20 Cattle graze from Aug-Sept on 15.56 ac (= 6.3 ha)	16 Cattle Aug-Nov on 8.5Ac (3.44 ha)		Aug-Nov 25 Cattle on 20 ha			Aftermaths grazed

Table 18 Continued:

Site Name:	Arkle Beck 1	Sutton Lane 2	Whitevine 3	Goldborough 4	Barrowburn 5	Barrow 6	Lee Farm 7
Last FYM application	Jan - Mar 94	?	Sept 91	Sept 93	1975?	March 93	?
FYM Frequency:	Every 12-18 months	1 in 3-5 years	1 in 3 yrs	2 years in every 3 yrs		One in 26 yrs?	1 in 3-5 yrs
FYM Timing:	Usually Jan-Mar but 1 yr in 4 in Aug-Sept	?	?	?		March-when dry	?
FYM Rate:	Manager estimates 5-10t/ac but 10t/ac by calculation (= 25t/ha)	1.82t/ac is the manager's estimation 7.5t/ac by calculation assuming 1 yrs production is applied (= 18.5t/ha)	2.24t/ac by manager's estimation: 9.4 t/ac by calculation (=23.2t/ha)	Equivalent to approx. 3.6t/ac/yr (=9t/ha/yr)		10t/ac (=25t/ha)	8 t/ac (= 20t/Ha) Max
Age of FYM	0-4 months		8-9 months	2-24 months		?	?
FYM Limits	Management Agreement/No of stock/ season/ weather	No. of stock and distance	Management agreement limits FYM to 8 t/ac (=20t/ha)	Conservative approach of farmer		No FYM produced on farm	Management Agreement/ holidays
Effect of FYM	Increased lushness	None apparent	Increased green winged orchids (*Orchis morio*) *			No effect on species diversity seen.	
	Increased grass growth		Decreased fragrant orchids (*Gymnadenia conopsea*)			10% less if unmanured	
	Decreased % cover of herbs		Increased clovers (*Trifolium* spp.)				

Table 18 Continued:

Site Name:	Arkle Beck 1	Sutton Lane 2	Whitevine 3	Goldborough 4	Barrowburn 5	Barrow 6	Lee Farm 7
Changes noted or planned	Increased *Bromus mollis* Increased *Stellaria media* Increased Docks (*Rumex* spp.)	None apparent	Increased vetches (*Vicia* spp.)	Reduction in manure application would seem desirable so fertility levels are kept as low as possible	National Park wish to see traditional inputs of FYM re-started. Trial to be under-taken first.	National Park wish to see traditional inputs of FYM re-started. Trial to be under-taken first	Farmer complains of lower hay crop in recent years. He suspects due to high levels of yellow rattle *Rhinanthus minor* and plantain *Plantago* spp.
Why?	Weedy straw suspected	-	-	-	-	-	-
Effect of no FYM	Sward shorter (10cm less). Sward thinner. Higher % fine grasses. Higher % of herbs. Roughly 20% less yield of hay when FYM not applied to 1 field in 1991.	N/A	Grass growth decreased	Vegetative growth & density reduced. Abundance of herbs varies with ability of *R. minor* to compete with grasses. Fear that if fertility increases less *R. minor* is likely to occur.	-	Suspect greater drought suscep-tibility Site can dry out in hot periods and make sward extremely light	-
Comments	1990 bought in hay/straw probably weed infested *Stellaria media* increased in non-SSSI meadows; *B. mollis* (and *Rumex* spp ?) increased in SSSI. Straw source changed in 1991		* This contradicts Silvertown *et al* 1994b who advise avoiding use of any organic or inorganic fertilisers to prevent reduction of *O.morio* numbers	Would start from no FYM application unless good reasons found to do so. Recognises benefit to agricultural production and need to dispose of FYM and possible benefit of return of viable seeds to soil.	-	-	-

Table 19. Summary of replies by English Nature Local Teams to a survey undertaken in 1994 for this report enquiring into current practice on conservation sites and their opinions

	Bradwell Meadows 8	Snaper Farm 9	Mottey Meadows 10	Greenhaugh (The Bog) 11
Soil	Millstone Grit overlain by SCL	LS/SL Org LS	Peaty	Silty Clay MG3
NVC	MG5a	MG5	MG4	Poor - occasional flooding
Drainage	Good	Good/Moderate	Occasionally flood	
Inorganic N	Suspect application in 1986	)) none)	)) None)	-
P				-
K				-
Lime	NI	Yes 3t ha-1 in parts	None	Yes in 1989
FYM applied	Yes	Yes	Yes on 4 out of 25 meadows	
Hay cut	In mid-July	Mid-July onwards	Mid-July-August	After July 20, sometimes late Aug
Hay yield	NI	0.26 - 0.65t/Ac (0.65 - 1.62t/ha)	NI	1.71-2.15t/Ac originally (4.2 -.5.3t/ha) 1.43t/Ac in 1993 (= 3.5t/ha)
Grazing -	Aftermaths only	1 April - 15 May Ewes and lambs 28 July- 30 Oct Cattle and ewes	1 Sept- 31 Oct Sheep on 6 out of 25 fields @ 4 per acre	End March-April. 20 Border Blackface ewes + lambs at foot
	Details unknown	30/Oct-28/Feb Ewes	1 Sept-31 Oct H x F cattle on 19 out of 25 fields at 1per acre	After hay cut for up to 2 months - 20 ewes and around 30 lambs
Last FYM applic. date	?	(Spring '93 to grazing pasture?)	Jan '93	
FYM frequency	1 in 3 years	1 in 2 years?	1 in 5-20 years	None
FYM Timing	?	Spring - from last record	Jan - from last record	
Notes		FYM turned over twice/ cross harrowed after spread		
FYM Rate	12.4t/ha-1 Max	20t/ha-1 Max (on pastures 17.8t/ha-1 estimated)	2.5t/ha?	
Age of FYM	?	3-4 months on average	12 months	
FYM Limits	Management Agreement	Limited FYM supply/P Wells agreement years ago	Licences/weather/availability of FYM/Distance	Management Agreement and rain!
Effect of FYM	None noted	None noted	Increase in vigour	

Table 19 Continued

	Bradwell Meadows 8	Snaper Farm 9	Mottey Meadows 10	Greenhaugh (The Bog) 11
Changes noted or planned	Species abundance has decreased; due to inorganic fertiliser?	Remained the same, but hoping FYM will help to improve soil water retention and modestly increase hay yields for farmers' sake.	None planned. Species abundance has increased.	Deterioration of species abundance and hay yields.
Why?	Suspected application of inorganic fertiliser prior to notification	-	Improved regulation of cutting dates, grazing dates, restriction of fertiliser.	Change in management - in past cattle grazed over winter and for short periods in bad weather - provided more dung than current regime.
Effect of no FYM	?	Perhaps slightly less growth in sward	Reduction in yield of hay crop.	-
Comments:	Farmer concerned about dominance of yellow rattle which he suspects has reduced hay yield in recent years. Uneasy about grazing cattle as might lead to spread of *R. minor* to other improved/semi-improved pasture.	Sward has very low nutrient status - dominated by eyebrights *Euphrasia* spp.and *R. minor*. Not clear why - drought or low nutrients suspected. The *R. minor* also reduces grass height. An excellent research opportunity! Sward weed free. The first FYM being applied to some fields for many (20+) years.	-	No FYM has been applied but reduction of stocking over the winter has made the field poorer. Recently (last 2 years) rushes increased.

9.5 Notes regarding Arkle Beck Meadows from ADAS reports for English Nature

9.5.1 Hay quality is undoubtedly affected by the weather, particularly mould is encouraged if hay is damp.

9.5.2 Yield varies due to leaf shatter and dry matter lost as the crop dries. Wind loss can vary.

Table 20. Hay yields at Arkle Beck; comparing: unrestricted fields which receive about 2.5 cwt 20:10:10 acre^{-1} year^{-1} + FYM with restricted fields receiving 5 -10t acre^{-1} year^{-1} + FYM

Hay yields @ 85% DM	Unrestricted management fields (t/ac)	Restricted fields (t/ac)
In 1988	2.46	1.82
1989 (a dry year)	2.145	1.298
1990 (a wetter spring)	N/I	2.186
1991	2.33	1.93
1992	1.86	1.86
Mean	2.20	1.82

9.5.3 It is speculation to suggest that the general drop in yields in the unrestricted fields is due to an increase in stocking density and later shutting up dates to compensate for the losses on the restricted fields (written in 1989).

Table 21. Adjusted hay yields @ 85% DM from Field 1 (a restricted field) at Arkle Beck during the period 1987-1992 (Accuracy + 2% claimed)

Year	t/ac
1987	1.50
1988	1.71
1989	0.96
1990	2.19
1991	1.98
1992	1.90
Mean	1.71

Note: Variation in yield = up to 44% between years @ 85 % DM

9.5.4 Fields usually yield similarly in the same year, but occasionally they yield exceptionally. Bale weights vary considerably - on different fields in the same year - ranging from 37.2-58 lbs (16.90 - 26.4 kg). Dry matters vary in the same year - 60-79% and between years from 60 to 88.1%. Usually DM is about 75% at the time of baling.

9.5.5 **It is critical that this variation is recorded for individual field and site analysis; if only by counting bale numbers roughly and weighing 5 bales per field with a dry matter test on a representative sample of hay from each field. Hay analysis is in the interests of the person feeding**

the livestock to ensure an appropriate ration is fed; so perhaps the costs can be shared?

9.6 Current rates of FYM applied to unimproved meadow SSSI's where such information exists

Table 22. Rates of application of FYM found by the survey

Site	Rate (t Ac^{-1})	Period in years	Equivalent Rate per year (t Ac^{-1})	Equivalent Rate per year (t Ha^{-1})
Arkle Beck	5 - 10*	1 in 1 - 1.5	8.3 Ø	20. 3 Ø
Sutton Lane	1.82 - 7.5*	1 in 3 - 5	1.5-2.5 Ø	3.7 - 6.2 Ø
Whitevine	2.24 - 9.4*	1 in 3	3.13 Ø	7.75 Ø
Goldborough	3.2-4.0	Every year, or 2 in 3	2.4 - 3.6	6.0 - 9.0
Barrowburn	N/I	?	?	?
Barrow	10	1 in 26?	0.5?	1.25?
Lee Farm	8	1 in 3 - 5	1.6 - 2.67	4.0 - 6.6
Bradwell	5	1 in 3	1.67	4.1
Snaper Farm	8	1 in 2	4	10.0
Mottey Meadows	1?	1 in 5 - 20	?	?
Greenhaugh	Nil	N/A	None	None

* = lower figure is manager's estimate and the upper figure is from calculation using information supplied by manager regarding straw use, housing period and stock no's.
Ø = using calculated FYM application rate where * used.

9.6.1 The equivalent rates taken on an annual basis from the fourth column of the table above are much lower than the 5 t ac^{-1} $year^{-1}$ (12.5 t ha^{-1} $year^{-1}$) maximum rate allowed in ESA's under MAFF management rules. However, the accuracy of some of the above rates is open to question, at present. **There is an urgent need for checking and accurate recording in future.**

9.7 Timing and periodicity of FYM applications

Table 23. Timing and peridocity of FYM applications: 1994 survey data

Site	Usual timing of FYM application	Date of last FYM application	Period in years between FYM applications
Arkle Beck	Jan- Mar ; but 1 year in 4 in Aug-Sept	Jan- Mar 1994	1 in 1 - 1.5
Sutton Lane	?	?	1 in 3 - 5
Whitevine	?	Sept 1991	1 in 3
Goldborough	?	Sept 1993	1 in 3
Barrowburn	?	1975?	?
Barrow	March when dry	Mar 1993	1 in 26?
Lee Farm	?	?	1 in 3 - 5
Bradwell	?	?	1 in 3
Snaper Farm	Spring?	Spring 1993?	1 in 2
Mottey Meadows	?	Jan 1993	1 in 5 - 20
Greenhaugh	None	None	N/A

9.7.1 The number of question marks above is indicative of a need to keep better records, and these were from staff who made the effort to respond to the survey request and so deserve thanks and praise. It is also worth noting that September was a time of application on two of these meadows when one could expect poor utilisation by herbage possibly with leaching and possible run-off, so giving a pollution risk, even if this timing reduced nutrient enrichment (due to the FYM nitrogen content) which may be desirable from a conservation view-point.

9.7.2 It is interesting to see the range of periods between applications. From the guidance given by Jefferson (in Crofts & Jefferson, 1994) one might have expected applications every three to five years.

9.8 Storage of FYM

Table 24. Storage of FYM 1994 survey data

Site	Age of FYM when spread (months)	Place of storage after mucking out
Arkle Beck	0 - 4; but up to 11 months	Outdoors 1 year in 4
Sutton Lane	?	Outdoors
Whitevine	8 - 9	Indoors
Goldborough	2 - 24	Outdoors
Barrowburn	?	?
Barrow	?	?
Lee Farm	?	?
Bradwell	?	?
Snaper Farm	3 - 4	Outdoors, and turned over twice
Mottey Meadows	12	Outdoors
Greenhaugh	N/A	N/A