Chapter 2 - Farming Animals: pastoral farming, possibilities and strategies

> '*Sheep and goats…required far more management then than the familiar idyllic picture of a small boy setting off with a flock into the hazy middle distance. Such pictures, borrowed from hotter climes, are totally inappropriate for temperate climates. Certainly, by the Iron Age…the middle distance probably belonged to someone else*' (Reynolds 1987:41).

The above quotation presents us with the key issue of identifying how animals and people inhabited landscapes. Livestock management involves constraints which are both externally derived such as the requirements of animal physiology and environment, and culturally derived, such as choice over herd management strategies (Reid 1996:44). Where differences in subsistence strategy over a wide area cannot be fully explained by ecological issues, there must be some cultural choice (Robertshaw and Collett 1983:76). However, we must deconstruct the elements of pastoral farming in order to understand their components and postulate particular strategies. The way in which animals are husbanded, and the items for which they can be exploited flow essentially from three considerations: the nature of the animals themselves, the nature of the landscape, and the choices employed to achieve a range of outcomes in a particular social setting.

2.1 The nature of the beast: the needs of livestock

Understanding pastoral systems must start with the animals themselves. Sheep are probably the easiest livestock to maintain, although an old adage is that a sheep is either fit and well, or dead (Reynolds 1987:44). Cattle are generally hardy and relatively self sufficient. The natural rearing method is uncomplicated and little intervention is needed (Manolson *et al* 1988:183). 'Primitive' breeds of sheep are unimproved varieties probably most like those which were farmed in the past. The Soay probably equates best with early sheep in appearance and characterisitics, and indeed has been suggested to be a 'survival' of Bronze Age sheep (Ryder 1981:184). Mature ewes weigh only 25kg, with fine bones and a short tail. It is horned in both sexes. They are hardy and thrifty. Later prehistoric horses are likely to have been similar to the small hardy ponies native to Exmoor. It has been claimed that these

animals represent the remnant of an ancient population. Whether or not, short rugged and thrifty horses were recorded in Cornwall in the early 17th Century AD (Dent and Goodall 1962:246). Small rare breeds of cattle, and rare breed pigs bred with wild boar, have been used as proxys for ancient animals, but there is little research or data specifically on these breeds' requirements. Whilst past domesticated livestock were probably different in some respects from modern animals, fundamental aspects of biology and behaviour are likely to have been similar, so information on modern animals is presented here as a guide (Tables 2 and 3), with comment on historical and ethnographic examples where available. Whilst these analogies cannot act as direct analogues for what happened in later prehistory, they alert us to the range of possibility that we must consider.

Animals probably also had similar reproductive cycles and herd structures (Table 4) in the past which would dictate the rhythms of the pastoral farming year, and are important to take into account when considering culling profiles and the associated decisions. A reflection of these concerns is preserved in the festivals of the 'Celtic' year (Hamilton 2000a:61-2).

Table 2: Lifespan of domestic livestock

Lifespan	
Sheep	
• Up to 20 years. • Often broken mouthed at 5-6 years • Frequently kept until 9-10 years.	Feral soay ewe, St Kilda recorded as 15 years old (Catchpole *et al* 2000). Early 19th Century 'guide sheep' reached 20 years (Fraser 1947:58). Modern sheep are often culled at 5-6 years (Goodwin 1979:84; Hart 1994:36), the same as in the 18th Century (Davis 2002:53-4).
Goat	
• Similar to sheep	Frequently kept until 9-10 years (Salmon 1981; Blake 1990).
Cattle	
• 20+ years	Will calve well into their teens (Young 2003). Similar in the 17th and 18th century (Davis 2002:49).
Pig	
• 10+ years	Skeletally mature at 2 years (Goodwin 1973).
Horse	
• 30+ years	Horses are skeletally mature at four years of age (can breed earlier) and can have a working life of more than twenty years (Houghton Brown and Powell-Smith 1984).

Table 3: Disease problems in domestic livestock

Disease problems	
Sheep	
• Foot rot • Parasites • Flystrike • Infectious disease • Age related joint change	Foot care involves cleaning out the cleft between the toes, removing stones and trimming the hoof back, generally using a paring knife. This cuts away infected tissue and treats foot rot (Bryce and Wagenaar 1985:39). Identical foot care is described by Fitzherbert (1534). Sheep blowfly affects 80% of modern British farms with 1-1.5% of sheep affected and leads to weight loss and ultimately death. The fly, active in spring and summer, lays its eggs close to the skin in areas of soiled fleece and can be avoided by removal or soiled fleece (Street 1942:90; Wall *et al* 1993:743). Cutting away fleece and treatment of scab with animal fat salves was recommended by Fitzherbert (1534). A certain level of disease resistance can be achieved by introducing new blood into the flock via the ram (Fraser 1947:162-3).
Goat	
• Foot rot • Parasites • Flystrike • Infectious disease • Age related joint change	Similar treatments recommended as for sheep (Salmon 1981;Blake 1990).
Cattle	
• Parasites • Infectious disease • Foot problems • Mastitis • Age related joint change • 'Work-related' disease	A range of diseases of cattle and other livestock that in some cases can be equated with identifiable modern problems were noted in the early Irish literature, and knowledge of internal parasites is retained in charms (Kelly 2000:194-213).
Pig	
• Parasites • Infectious disease	Pigs are particularly susceptible to respiratory illness, but suffer from a wide range of diseases (www.thepigsite.com; Allen 1910:160-185).
Horse	
• Parasites • Foot diseases • Infectious disease • Age related joint change • 'Work-related' disease	Lymphangitis and laminitis are painful diseases of the feet causing lameness caused by an overly rich diet for the amount of exercise the animal is getting (Frazer 1988:201,211; Houghton Brown and Powell-Smith 1984:7). The aetiology of laminitis involves an intolerance to glucose affected by the type of fodder, and exacerbated by mud; rotation of grazing assists in controlling this, avoiding rich new grass (Watts 2004:88,95).

Table 4: Breeding timetables and herd structure

Breeding timetables and herd structure	
Sheep	
• Sexually mature at 6-8 months. • In season in the autumn, repeating the heat at 14-19 days (Fraser 1947:38). • Gestation 147-151 days (21 weeks).	A single lamb per ewe is the natural lambing rate (Barker 1985:41). Modern British breeds regularly produce twins and occasionally triplets; single births for hill sheep, multiples in the lowlands (Fraser 1947:31). The peak in fertility is normally achieved at the fourth or fifth lambing, declining thereafter, with the least fertile ewes those bred

• Lowland flocks generally lamb February-April (Goodwin 1979:80; Hart 1994:40). • One ram lamb in 30-50 will be allowed to breed (Fraser 1947:22). • A lambing percentage (surviving lambs produced per 100 head of ewes) of 50% is just sufficient to provide replacement female animals (Frazer 1947:58).	before one year old; they take the ram two months later than older ewes (Fraser 1947:40;61). If a short lambing period is desired, more than one ram may be required even with a small number of ewes in order to ensure service in a short period (Bryce and Wagenaar 1985:45). Lambing rates for modern hill sheep can vary between 40% and 90% (Hayes 1981:117). The Soay lambing rate is 130%, and lambs are heavy in relation to their own body weight, with a high relative milk yield (Alderson 1988:107). Similar rates are characteristic of the slightly larger and frequently multi-horned Hebridean and Manx Loghtan breeds (Alderson 1988:107). When population density for feral Soay sheep is low, the natural mortality is below 10% in an year, whereas it can rise to 90% for lambs, 70% for yearlings and 40% for sheep two or more years old (Catchpole *et al* 2000:454). Soay sheep with lower parasite loads and more efficient grazing due to tooth shape have displayed greater over-winter survivability (Illius *et al* 1995). The breeding pattern was similar in Early Medieval Ireland (Kelly 2000:69), and appreciation of the need for different tupping dates dependent on the location of flocks, and availability of spring forage at weaning is apparent in 16th and 17th Century English farming texts (Davis 2002:52). 17th and 18th Century texts recommend one ram to between 30 and 120 ewes (Davis 2002: 52).
Goat	
• Females become sexually mature at nine months. • Males can be fertile from 3-4 months of age and need be reared separately (Salmon 1981:82,86-7). • In season September - February leading to extended kidding in spring. • Oestrus lasts 1-3 days and is repeated after 21 days. • Gestation 145-155 days (21-22 weeks). •	When in season between August and February the males spray themselves and exude an awful smell. Milkers are generally mated as yearlings and then every other year. Modern goats will milk for 22 months. Twins and triplets are frequent (Salmon 1981:87,89,96; Blake 1990:197; 1994:196).
Cattle	
• Heifers reach puberty around 12 months old but are not normally bred under 14 months because this can cause calving and other problems. • Gestation lasts *c*285 days (nine months) (Smith Thomas 2005:117-8) • Generally single births although twins are more common in modern breeds.	Building herds can be a slow process with small numbers of animals; on a Cotswold farm in the 1920s a pair of cows was increased to ten, in ten years (Henderson 1944:65). Knowledge of the value of heredity in selecting breeding animals is attested in Early Medieval Irish texts (Kelly 2000:50). It has been traditionally common practice to put heifers to the bull so that they calve at three years in Britain and Ireland, or later, possibly relating to poor winter feed availability (Kelly 2000:37; Davis 2002:49). Calf mortality in Mali occurs at c10% in traditional extensive systems utilising either tethering or penning, less than that for modern intensive methods (Wymann *et al* 2006:170,174). Digestive tract disorders, perinatal mortality and accident accounted for most of the losses (Wymann *et al* 2006:175-6). 'Nurse' cows will allow several calves to suckle (Manolson *et al* 1988:184). Most cattle in early medieval

	Ireland were born in May (Kelly 2000:41). English sources for the 16th -18th Century indicate a range of calving periods from February to May, and a range of ages at weaning between four and twelve weeks, and utilisation of the good grazing is stressed (Davis 2002:49). One bull to 50 or 60 cows was required in the 17th Century (Davis 2002:49). They were generally kept in small numbers; a number of inventories from the Vale of Berkeley from the 16th-18th century were between nine and 18 cows. A large herd recorded at Horsely in 1613 consisted of ten cows, five two-year-olds, 15 yearlings and seven calves, two fattening steers and an eight-ox plough team (Stout 1993:23)
Pig	
• Females are sexually mature at 5-6 months; early matings can affect growth and health. • In heat every 20-21 days, lasting 12-36 hours and farrow several times a year (Goodwin 1973:124). • Gestation 112 days (16 weeks) (Allen 1910:25). • Boars sexually mature c4-5 months of age, normally 7-8 months before used. • A mature boar can serve up to 40 sows over the course of a year (Goodwin 1973:94-5), but one boar to twenty sows is more normal (Blake 1990:200).	In the Mediterranean pigs farrow at practically any time of year (Albarella *et al* 2007:305). In the 17th century it was recognised that a sow could be fertile until about seven years of age; farrowing two or three times a year was common (Davis 2002:56). Wild boar generally come into season in autumn (www.britishwildboar.org.uk), but it is not established how long this feature was retained. When there was a single farrowing this would be in spring (Albarella 2006:84). Pigs are normally weaned at about eight weeks of age (Goodwin 1973:37-9,124). Medieval pigs produced *c*6-7 piglets per litter (Barker 1985:34-5), although of 12-16 were common (Markham 1657:100).Boars need to be kept separate from the female pigs, but behave better if in sight of them (Goodwin 1973:94-5). During the 16th-18th century, both boars and sows were neutered in order to produce greater meat weight, but the time at which this was carried out varied (Davis 2002:56).
Horse	
• Sexually mature at two years. • Mares in season for a few days at a time every three weeks in late spring and summer. • Gestation is eleven months . • Foals generally weaned at 4-6 months (National Equine Welfare Council 2005)	Stallions in the late 17th Century could cover 15 or 20 mares, beginning at the age of three and continuing until 20 years of age, whilst mares could begin breeding at two years ending around the age of 10-14 (Davis 2002:55). Pregnancy is generally uneventful (most horses can continue being worked up until the last month) and most mares foal in the field with no assistance. Mares will seek isolation from other horses in the first hours and days of life due to the drive to establish a strong mare-foal relationship; separation causes great distress in both parties (Hausberger *et al* 2008:11). On hill land foals will continue suckling until the food supply reduces with the winter weather (Frazer 1988: 197,206-207,214). New Forest feral horses wean at 8-9 months, and horses living in extensive grazing begin to graze at a few weeks old, whilst obtaining most of their nutrition from their mother. This avoids checking in growth (Waran *et al* 2008:47). First year mortality rates in feral horses in North America have been estimated at *c*40-50%, partly explained by the arid environment (Wolfe 1980:357). Horses were bred in Early Medieval Ireland, and the law codes indicate that foals should not be separated from the dam. They were supposed to be kept confined lest they damage crops (Kelly 2000:92-3).

2.2 The constraints and opportunities of landscape

'*The stock, like us, will pass on, the land will remain*' (Henderson 1944:95).

In addition to the basic needs of livestock, the type and nature of a pastoral agricultural system will always be related to the natural and anthropogenic landscape in which it exists. Where conditions are not ideal for animals, adaptations can be made via husbandry practice that modifies that landscape; meanwhile, any system and concomitant adaptations must fit into the social landscape of labour and concepts of ownership.

The types of livestock raising strategies, and type and scale of arable production, are constrained by a number of issues. Topography, height, exposure, soil type, and rainfall all affect the success of particular strategies. For example rainfall, retention of water in soils, and the process of run-off alters the quality and nutritional value of pasture, as well as arable. The whole of lowland England lies within the area where rainfall deficit can equal or exceed the reserves of moisture held over from winter within rooting depth. Whether or not the vegetation suffers badly from drought depends on the moisture capacity of the soil. Modern farming has adapted to these conditions with stock-rearing practised where grass grows throughout the summer, and cereals concentrated in dryer areas, as their root depth is greater than grasses, and they mature early. Summer grazing of flood meadows provides rich hay (Limbrey 1978:24-5). The availability of flowing water provides a constraint in pastoral farming, but can be dealt with by changes in management.

Soil types tend to favour particular practices. For example, on heavy Sussex Weald clays in the later medieval period, the soils were often too wet to be suitable for barley or sheep. They were however suitable for beans, the surplus of which was used to fodder specialised pig production; in this case their utilisation was due to external market forces (Mate 1997:259). This illustrates how practical responses occur in tandem with social choices. Height and degree of slope affect arable cropping more than pastoral agriculture. Livestock can successfully graze relatively steep slopes, whereas physically tilling soils on slopes is problematic and can lead to considerable

erosion (Limbrey 1978:25). Extensively husbanded sheep and goats have been widely regarded as one of the most effective uses of 'marginal' land in the modern period (Bertaglia *et al* 2007:657). It is also far easier for pastoral husbandry to develop responsive strategies to adverse weather; animals are mobile.

2.2.1 Required components for livestock husbandry

The wildlife management concept of 'optimum habitat' has been applied to livestock husbandry. It generally applies to the optimum conditions to support the highest density of a species (Bailey 2005:110), but needs adjustment to take into account management choices and aims. It necessarily introduces the concept of sustainability, the ability of a given strategy to be stable over a period of time. For example, in extensive pastoral systems it assumes optimisation of animal performance whilst ensuring the indefinite continued availability of pasture. The main factors are those which affect the effort to find food (availability of water, slope, distance over uneven terrain, shelter from sun or bad weather) and the food itself (quantity, quality and heterogeneity) (Bailey 2005:110-112). These follow in part from the behavioural characteristics of particular animals (livestock generally avoid areas far from water, higher elevations and steep slopes due to the additional daily effort of getting to water (Bailey 2005:116)), and from the level of intervention by people in pursuit of the required goal. This interaction of intervention and behavioural mechanism is illustrated in Table 5.

The main areas where there are physical and behavioural drivers for livestock which can be catered for by artificially altering the landscape are:

- Water (See Table 6);
- Grazing and Fodder (See Table 7);
- Handling, containing and housing, enabling intervention in breeding, veterinary treatment and 'harvesting' (discussed below).

Availability of water is a critical factor in livestock behaviour. In order to utilise land, as detailed in Table 6 water must be available or made so. This is particularly important if animals are kept in areas without access to natural water sources, but has wider

effects. Studies of free-ranging livestock have indicated there can be a marked drop in forage utilisation the further away from a water source whilst angle of slope and vertical distance above water emphasises the effect (Bailey 2005:110). Reduction in pasture size, enabling access to water may increase forage utilisation (Hart *et al* 1993).

Table 5: Effects of grazing distribution practices on behavioural mechanisms affecting the selection of feeding sites by livestock in North American Rangelands (After Bailey 2005:114).

Management Practice	**Effect on Habitat factor**	**Behavioural mechanism affected by management or consequence to animal**	**Expected change in grazing distribution by management**
Water source development	Horizontal and vertical distance to water will be reduced in some areas of the pasture	Reduced effort to travel to foraging sites near water development	Increased grazing use near water development
Trail development	Paths are developed in the pasture typically in rough terrain	Reduced travel effort to foraging sites near developed trail	Increased use of areas near developed trail
Fencing	Terrain and plant communities enclosed	Available choices of feeding sites	Livestock can be restricted to certain sites and excluded from others; opportunity to increase homogeneity of enclosed vegetation
Burning or fertilisation	Forage quality and quantity may increase in treated sites	Nutrient capture rate may increase in treated sites	Livestock will prefer treated sites over untreated sites
Strategic supplement placement (inc salt/mineral licks)	NA	Palatable feed available at certain and sometime distant feeding locations; after travel to supplement, travel effort to nearby feeding sites is minimal	Animals are lured to areas near supplement placement
Selection of more adaptive breeds or individual animals	NA	Perceived travel effort for adapted animals is less than for un-adapted animals	Selected animals will travel further and use rougher terrain
Herding	NA	Animals are not allowed to travel directly to the feeding site they selected and are herded to another location	Feed site for the herd is selected by management

Table 6: Watering domestic livestock

Watering	
Sheep	
• Sheep obtain most water from grass.	Water should always be available (Goodwin 1979:169).
Goat	
• Up to 27 litres per day (Salmon 1981:31,52,58).	Will not drink fouled water, and can be wasteful. Need less than sheep, but increased by low quality feed (Morand-Fehr 2005:31).
Cattle	
• Need a constant supply of water (Smith Thomas 2005:16). • 40-50 litres (up to 75l if housed) of water a day (Reynolds 1987:41).	Calculations used by Reynolds were for high yielding modern dairy cattle (Slater 1991:44). Data for smaller and primitive breeds is unavailable.
Pig	
• Adult pigs need 5-8 litres per day. • A lactating sow can need 15-30 litres (Defra 2003:20).	Pigs cannot live for more than 72 hours without water (Goodwin 1973:134).
Horse	
• 20-70 litres daily depending on temperature and humidity, bodyweight, activity and health (National Equine Welfare Council 2005).	Access to water is essential, and more is required if the animal eats a large amount of dried food. An average hunter, stabled, requires 37 litres per day (Houghton Brown and Powell-Smith 1984:154).

Table 7: Foddering domestic livestock

Fodder	
Sheep	
• Majority requirement provided by grass • Will browse (Pryor 2006:41) • winter feeding 2kg of hay daily for modern breeds (Seymour 2003:114). • mineral supplements are generally unnecessary (Fraser 1947:77).	Sheep losses tend to be higher in spring when the animals are in bad condition when they are lean (Fraser 1947:165). Ronaldsay sheep on Orkney have adapted to eat seaweed but suffer liver damage from copper uptake as a result (Haywood *et al* 2005). Seaweed eating has also been observed in sheep on Lundy, Devon.
Goat	
• Grass is most important, either fresh or as hay, but browse is important. • Modern dairy goats daily intake is 1llb (450g) concentrates, 5lb (2.25kg) hay and 10llb (4.5kg) greens, branches or roots; milkers need additional protein (Ross 1989:48,51). • Goats need four times as many minerals as sheep (Blake 1994: 196). Particularly useful for milkers, who excrete salt in their milk (Ross 1989:50; Halliday and Halliday 1988:85).	The digestion of goats is similar to cattle and sheep but they are better able to ingest and digest forage rich in cell wall and poor in nitrogen (Morand-Fehr 2005:31). They need large amounts of carbohydrate with some protein. In the last few hundred years green crops including lucerne, comfrey, oats, vetches, and root vegetables have been fed, with pea and bean plant waste, bolting lettuce, spinach, apples and brassicas. Kale and mustard are particularly useful for over-wintering and cereal chaff provides roughage (Halliday and Halliday 1988:83; Salmon 1981:59). Analyses of Neolithic sheep/goat faeces in Switzerland identified hazel, elm and alder pollen and plant macrofossils. At Egolzwil, Neolithic goat faeces were found with piles of twigs suggesting browse collected. The pollen suggests spring fodder prior to leaf emergence (Rasmussen 1993). Pollen in faeces at Arbon Bleiche indicated the season of grazing (Akeret *et al* 1999). Goats with worn teeth will adapt

	their diet (Mellado *et al* 2005). Morning and evening feeding routines are common (Salmon 1981:17,52,58), but there is no necessity for a fixed feeding routine. Kelp can be used to combat iodine deficiencies (Salmon 1981:60).
Cattle	
• Can be entirely sustained on grass. • The winter hay requirement for a small cow is c1000kg (c1500kg if milking) (Seymour 2003:97-8). • Nutritional needs increase in the last trimester of pregnancy (Smith Thomas 2005:125); for a spring calving, fodder need peaks before grass is growing. • Salt is recommended as it stimulates appetite (Smith Thomas 2005:27).	Over winter and early spring, cattle tend to lose condition, so can be fed hay, straw and grain. To obtain good growth a steady good quality diet is required (Manolson *et al* 1988:178). One estimate in 1851 was that three acres (1.2ha) was required to produce winter hay for a single cow (Lake 1989). Entirely grass-fed animals are leaner (Smith Thomas 2005:102). Cattle can be fussy about muddy feed and will waste hay on damp ground (Smith Thomas 2005:18). Feeding needs to be supervised as bowel obstructions leading to bloat can be fatal. It is caused by poor quality hay, grazing on dry pastures, a sudden change to dry food or overeating on fresh green pasture, especially containing clover (Manolson *et al* 1988:191). Historically, seaweed was fed in coastal areas (Kelly 2000:42). Fish, fish offal and seal fat poured over hay were regularly fed to cattle in northern Iceland in the 19th Century (Amorosi *et al* 1998:47). Harvesting of oak, elm and ash leaves for cattle feed was recorded in the late 16th Century (Lake 1989:35). Elm was regarded in early medieval Ireland as the 'friend of cattle', but heather and furze were inferior fodder (Kelly 2000: 16,42). Bracken has been harvested in the past for fodder and bedding; heather and gorse can also be cut for this purpose, although gorse needs to be crushed before feeding (Smith Thomas 2005:27).
Pig	
• Pigs are omnivorous and can live on practically any form of food (Seymour 2003:106). • Grass can provide between 5-70% of required nutrition, depending on sward quality (Goodwin 1973:120). In wild boar this is 45-90% dependent on season (Hodgkinson *et al* 2009:222,225). • They can also be fed cereals, fish, milk and meat by-products, as well as other vegetable foodstuffs; meat and bone can be fed at up to 10% of the diet (Goodwin 1973:53; Allen 1910:90-1). • Some wild pigs will feed on marine vertebrates and invertebrates (Masseti 2007:162). • Pigs need protein rich foods during late pregnancy and lactation (Masseti 2007:162). • Pigs need a range of minerals, but most are obtained from green foods and rooting in soils	Pigs root in soil due to a love of worms, insects and roots (Allen 1910:118). They are opportunistic and show little preference other than vegetable over animal, but can predate small wild mammals and even juvenile sheep and goats (Choquenot *et al* 1997; Wilcox and Van Vuren 2009). They have simple digestive systems that deal inefficiently with large amounts of fibrous material. For optimum growth they need low fibre, high energy foods, and young pigs in particular can have their growth retarded by high fibre diets (Goodwin 1973:55). The proportions of carbohydrate to protein in pigs' diets affect the proportion of fat or meat (Bushby 1988:149). Grains, in particular milling residues, are used (Goodwin 1973:66). Feeding pigs on leftovers, cereals and dairy by-products may have a long currency as it is referred to in early Irish literature (Kelly 2000:82). Fish meal and oil provide high quality protein, but in large quantities can 'taint' the meat (Goodwin 1973:61-2). Consumption of marine resources has been demonstrated by stable isotope analysis of Late Medieval pigs in Flanders (Ervynck *et al* 2007:185). Deficiencies lead to a variety of diseases, such as anaemia (Goodwin 1973:58). Pig need salt if fed only vegetable matter, although it can cause problems if consumed in excess (Goodwin 1973:57). The use of a variety of waste products for pig rearing were noted in the 17th Century '*from the husbandman he taketh pulse, chaffe, barne dust, mans ordure, garbage, and the weeds of his yard; and from the huswife her draffe, swillings, whey, washing of tubs and the such like*' (Markham 1657:100). Stable isotope data from Middle Iron Age Wetwang Slack, Yorkshire, indicate that whilst

(Goodwin 1973:56-60).	younger pigs were probably weaned late or consumed dairy or meat products, adult pigs were entirely herbivorous (Jay and Richards 2006:661). Some less savoury habits have been utilised in the past, such as in South East Asia, with the 'pigsty-privy' arrangement that also provides a degree of disease control (Nemeth 1998), and indeed may fulfil the role of waste disposal (Masseti 2007:165-6). Pigs were traditionally fed in the autumn on nut mast, but this was only for the period of a couple of months, and sixteenth century tests advise the collection of mast and mixing it with other foods for feeding to housed pigs (Lake 1989:37). Mast consisted of acorns but also fruits of wild pear, apple and cherries, sloes, rosehips hazelnuts and other fruits (Vera 2000:123). Although medieval pig husbandry relied heavily on woodland, pannage was only available in the autumn, and were fed on pasture, housed or in yards (Trow-Smith 1957:53-81). Pigs could be out for a few weeks or up to four months (Vera 2000:123). It has been suggested that the term 'acre' derives from the area of pannage per pig as it and 'acorn' may have the same Germanic root describing mast (Vera 2000:124).
Horse	
• Most horse nutrition is from grass. • Browse of hedgerow herbs, twigs and bark; they chew earth (Houghton Brown and Powell-Smith 1984:162; Moore-Colyer 1994:9-10). • Oats and cooked linseed can be used as a supplementary feed for hard worked horses; green foods, apples and mashes of bran are laxative feeds (Frazer 1988:202; Houghton Brown and Powell-Smith 1984:152). • Vitamins and minerals are normally obtained from grass and herbs, and deficiency problems are rare, generally only affecting stabled animals (Frazer 1988:203), which, especially if fed bran, can suffer calcium deficiency.	Horses are continuous feeders, grazing for long periods all day and periodically dozing on their feet (Frazer 1988:199; Houghton Brown and Powell-Smith 1984:4). Horses need a lot of exercise and good condition is a balance between quality of fodder and work; overfeeding or incorrect feeding, in particular of fermenting food, can result in digestive complaints such as colic. Addition of linseed oil to fodder improves the uptake of nutrients without affecting palatability and avoids the risks of laminitis in high-starch feeding (Delobel *et al* 2008). They have an annual requirement of a tonne of hay, other supplementary foods and straw for bedding. They can do serious damage to trees, particularly in winter (Houghton Brown and Powell-Smith 1984:162). Wild horses in the Camargue feed where the best quality fodder is most abundant (Duncan 1983). Common Ragwort is poisonous to horses causing liver damage (The Weeds Act 1959; Code of practice to prevent the spread of Ragwort 2004).

2.2.2 Grass, grazing and grassland management

'*Keep ten sheep to the acre until each acre will take ten sheep*' (Henderson 1944:103).

Management of grassland is a neglected issue in relation to ancient animal husbandry. A considerable area of expertise for modern livestock farmers, crucial for maximising animal health and yield, it has not been considered as part of the expertise of ancient

livestock farmers. However, there is little reason to assume that prehistoric farmers did not understand the nutritional benefit differences between forages. Maasai herders in east Africa maximise cattle survival by their knowledge of the properties and locations of vegetation, which they utilise seasonally for particular benefits such as promoting lactation (Ryan 2005:100). Pasture is complex; it is not just 'grass', but a mixture of numerous grass and herbaceous species each with a range of ecological preferences. Some fix nitrogen, maintaining fertility or draw up minerals and nutrients, whilst others are invasive and unpalatable such as creeping buttercup or ragwort (Bryce and Wagenaar 1985:12). Some grasses have much greater nutritional value to livestock than others. New grasses, including perennial ryegrass, sainfoin, clover and trefoil were introduced in the mid 17th century, enabling long term fertility of grassland (Lake 1989:17). Preferred grasses in modern pasture mixes include perennial ryegrass, creeping red fescue, crested dogs-tail, smooth-stalked meadow grass, cocksfoot, timothy and tall fescue (Houghton Brown and Powell-Smith 1984:168). Hill grasses such as bents, molinia, cotton grass and fescues are poor quality species for fodder purposes (Goodwin 1979:40). The grasses present will depend on the nature of the soil (Frame 1992:79-84). The ideal pH for grass is 6.5; if soil is too acid, species that provide poor nutrition prosper, whilst if too alkaline grass cannot take up certain minerals (Houghton Brown and Powell-Smith 1984:167). On acid land nutritionally poor grasses such as bent, Yorkshire fog, mat grass and wavy hair grass develop (Seymour 2003:166). On wet land, tussock grasses, rushes and sedges develop, which are similarly bad for fodder (Seymour 2003:166).

Pasture can be managed in a number of ways to influence composition and productivity. Nitrogen dressings encourage grass at the expense of some other plants, whilst lime is needed in acid environments (Houghton Brown and Powell-Smith 1984:167; Frame 1992:119). On the chalk, marling has gone on for at least several hundred years, but the creation of burnt lime from limestone appears to have only been used in agriculture since the 16th Century (Archer 1988:25). Neglected grazing can, however, be improved by controlled burning of mats of dead grass, repeated mowing, and clearing ditches to improve drainage (Bryce and Wagenaar 1985:13-15). Weed infested pasture can be cleaned by ploughing up perennial weed roots and

burning them in spring (Street 1942:63). Burning pasture can improve grazing by enriching the soils with ash; the burning of heather has been identified in a 5-6th Century site in eastern Scotland by pollen analysis combined with particle size analysis of a burnt layer (Whittington and McManus 1998). Old pasture can be improved by ploughing up and reseeding (Seymour 2003:166). Re-seeding was known to the Romans, but it is assumed that its use, as well as during prehistory, was limited (Barker 1985:47). Whilst manuring is generally beneficial, grazing animals will normally provide enough, especially if there are nitrogen fixing plants present (Blake 1990:188).

Some weeds are grazed by livestock in their leafy state, but not when mature, and they can crowd out more nutritious plants (Frame 1992:69). Topping off weeds such as docks and thistles before they set seed prevents infestation, and encourages shorter grasses (Seymour 2003:166). Ragwort needs to be removed by hand as it is poisonous to some livestock and increases if cut (Houghton Brown and Powell-Smith 1984:169; Frame 1992:70). Bracken can be kept in check by frequent cutting, as can gorse, which also can be burned (Frame 1992:76,78). If grassland is cut for hay annually and the aftermath grazed, coarse large grasses such as perennial ryegrass and cocksfoot are encouraged whilst finer grasses and clover are suppressed, shaded by the larger species. If, however, grass is grazed hard, shorter species are encouraged (Seymour 2003:166). Permanent pasture, generally defined in modern British farming as being down for more than eight years, will normally have a diverse plant population, but can become run down and low yielding. However, correct grazing can prevent this, avoiding overgrazing and poaching (Blake 1990:187). Grazing maintains a diverse plant population by opening the sward to seeding (Watt and Gibson 1988:91). Shorter term lays as part of an arable rotation need to be reseeded to establish appropriately. Continued grazing can prevent successional change in grassland species, although the effects of changes of grazing in permanent pasture over 10 years of age is more limited than grazing recently established leys, and different species, timing and stocking rates have different effects (Gibson *et al* 1987:34).

Grass grows most vigorously in the spring, sets seed and then dies down. It hardly grows at all over winter, although the growing year may be as long as 10 months of the year, providing it does not seed (Seymour 2003:168). Grazing at different times of the

year has different effects on encouraging or deterring different plant species (Watt *et al* 1996). Spring grazing opens the sward to germination of additional species whilst palatable grass species produce more foliage when grazed (Gibson *et al* 1987:42). Different patterns of grazing, intensity, and duration have different effects on specific weed types, and can be adjusted to obtain a desired land management outcome (de Bruijn and Bork 2006). Encouraging the selective grazing of less nutritious species not only controls them but speeds soil nutrient cycling and plant growth (Harrison and Bardgett 2008:208).

Control of grazing is important for two reasons; utilization and sustainability of the resource, and maintenance of livestock health through avoiding parasite infestation and other diseases. As mentioned above, grassland consists of a wide variety of species of grasses and other plants. These vary spatially on a regional and landscape scale, but also locally. Grazing herbivores interact with this depending on palatability, accessibility and morphology (Searle and Shipley 2008:128-9; Frame 1992:176-7). Sheep will selectively graze and will eventually destroy the plants which they prefer to eat (Fraser 1947:103). Uneven grazing of extensive pasture by cattle is a widely recognised phenomenon (Ganskopp and Bonhert 2009:110-111). Slopes of more than 20% are avoided and the effect becomes greater with increasing steepness (Bailey 2005:110). Correct stocking rates are important in all systems as, in combination with the duration of grazing, they will prevent under or overgrazing. Overgrazing of pasture not only reduces the number of perennial plant species it contains but leads to poaching and adds to run off and erosion (Jones and Dowling 2005). Modern stocking is calculated in livestock units (LUs) (one cow = 1LU and five sheep = 1LU). In organic systems, sustainable stocking is recommended at 1.2 Livestock Units per hectare calculated across the entire holding (Blake 1990:51).

Ruminants have been shown to frequently fail to follow a predicted course of optimisation in their grazing. Examination of grazing habits on rangeland in Oregon has indicated that, rather than seeking out and selectively grazing on the basis of the plant matter alone, animals were grazing selectively based on the elevation, and proximity to watering places (Ganskopp and Bonhert 2009:111,118). Extensive grazing compared to intensive grazing of dry upland pasture appears to be more effective at buffering

the impact of year on year changes in the weather (Marriott *et al* 2009:199). Some studies indicate that accessibility of fodder to cattle grazing in woodland may be as important as palatability or nutritional value (Mayer and Huovinen 2007:378). This also draws our attention to the fact that when we consider grazing, the area need not be purely open grass, but include varying degrees of woodland, scrub and trees. It has been, and remains common practice in England and Northern Europe to graze woodland and orchards (Vera 2000:129-138). Modern regulations dictate what density of trees are allowable in counting land toward declarations of forage area for agricultural subsidy (European Commission 2004; Rural Payments Agency 2009:66).

Grazing and stocking also needs to be controlled in order to prevent 'poaching' of the grass sward by excessive trampling by stock. This can cause both erosion and soil compaction affecting pasture growth and can create conditions that lead to foot problems in livestock. Time of year, rainfall, stocking density and soil type all affect the degree of poaching that occurs (Frame 1992:85). Pigs can be grazed but cause enormous damage through rooting (Allen 1910:118; Goodwin 1973:120; Hodgkinson *et al* 2009:222,225). Different grasses will recover at different rates. Poaching can be reduced by field layout, the degree to which animals need to move around fields and the routes by which they do so, as well as removing the animals. Housing animals over winter is a popular modern remedy (Frame 1992:86,185).

Parasitical and other problems that can be controlled by grazing practice are given in Table 8. Parasite problems increase when livestock are densely stocked (Alderson 1988:136), and most can be controlled by managing grazing. Creep grazing is popularly used for young animals. The lambs are allowed the first grazing on the next pasture by way of barriers with small gaps that allow them through but which keep out the ewes. The whole system is rotated every 4-5 days and is both an effective intensive feeding and disease control regime, but requires knowledge and organisation (Goodwin 1979:97-8,173-4,191-98). Grazing a mixture of species on the same land is also effective, as different parasites attack different livestock (Alderson 1988:136). Mixed grazing with cattle, has the additional benefit of lowering the sheep stocking density and in turn reduces the worm load (Goodwin 1979:192).

Table 8: Control of disease by grazing management

Problem	Type	Species affected	Description	Remedy
Roundworm (*Ascaris lumbricoides*)	Parasite	Sheep, Goats, Cattle, Pig	Large numbers of roundworm can kill sheep, especially young ones, whilst poor nutrition weakens the animal and increases the numbers of worms retained in the gut .	This can be reduced by ensuring that land is not overstocked and rotational grazing (Fraser 1947:157-8) and has a limited lifespan on pasture of 4-7 days. Salmon 1981:49, 146-7). Young animals put onto clean pasture that has not had same species on it earlier in the year; older animals can then follow on. Harrowing and reseeding will destroy the worm larvae (Manolson *et al* 1988:187-189). They can be kept in check by frequent mucking out, but not eliminated (Goodwin 1973:183).
Tapeworm (*Cestoda*)	Parasite	Sheep, Goats, Cattle	Harboured in mites in grassland. Infestations peak between June and September, but only cause animals real harm when numerous.	Has a limited lifespan on pasture of 4-7 days (Salmon 1981:49, 146-7). Young animals put onto clean pasture that has not had same species on it earlier in the year; older animals can then follow on. Harrowing and reseeding will destroy the worm larvae (Manolson *et al* 1988:187-189).
Other worms	Parasite	Horse	Loss of condition, heart damage	Rotational grazing, following other livestock (Frazer 1988:213-214) with the cattle and sheep consuming the worms that are specific to horses (Houghton Brown and Powell-Smith 1984:167).
Liver fluke (*Fasciola hepatica*)	Parasite	Sheep, Goats, Cattle	Widely distributed and harmful parasite, particularly bad in wet summers and on damp ground (Fraser 1947:156).	Infestation is not entirely related to stocking density; can relate to general nutritional status and condition (Rees 1942). Complex lifecycle means fluke can survive on pasture in excess of 8 months and their capacity for reproduction presents a considerable problem (Salmon 1981:49, 146-7), so rotational grazing is of limited effect.
Ticks	Parasite	Sheep, Cattle	Skin damage and infections	Move cattle to clean pasture and avoid scrubland (Manolson *et al* 1988:187-189).
Lice, warbles, mange mites, bots	Parasite	Cattle, Horse	Skin damage and infections	Rotation of grazing, hygiene (Frazer 1988:213-214).
Foot rot	Infection	Sheep, Goats, Cattle	All ages are susceptible, badly drained land and wet weather can exacerbate it. Increased likelihood in cattle if they have to walk through mud, especially with chapped skin in cold weather. It results in lameness and weight loss. Untreated it can cause fever and septicaemia (Manolson *et al* 1988:193)	Can be passed onto the ground, although it can only survive there for seven days. Rotating around small paddocks of clean pasture can assist. Keeping animals separate can prevent infection spread (Salmon 1981:49, 146-7). The best prevention is to avoid boggy areas and ensure a dry area in winter (Smith Thomas 2005: 14, 47,142).

In 19th Century Dorset, cattle were housed in winter and sheep let into their pastures (Fussell 1948:57), a practice widely reported in the 20th Century (Fraser 1947:87). Liver fluke are more problematic (Salmon 1981:49, 146-7), but is should be considered that as they occur most prolifically in wet pasture, limiting grazing to seasonal use may be sufficient to avoid re-infestation. However, saltmarsh grazing is actually beneficial as it deters liver fluke and foot rot (Stallibrass 1996:59). Some modern breeds of sheep (e.g. the Romney) are naturally resistant to foot rot and parasitic worms (Fraser 1947:87). We have no way of knowing to what degree these traits may have been expressed in sheep in the past, but it is likely that people were fully aware of the cause and effect of keeping animals on the same pasture for too long.

In order to manage grazing, a number of strategies are available, and these are based on the information in Tables 9 and 10. Modern organic farmers are advised to keep more than one type of livestock in order to utilise their differing grazing techniques in grass management (Blake 1990:18). Cattle wrap their tongues around grass and need it to grow longer than sheep, which can get closer to the ground due to a split upper lip (van Wijngaarden-Bakker 1998:176). For each cow kept, you can keep a sheep without additional grazing (Blake 1990:192; Fraser 1947:86). Cattle and sheep grazed together can attain greater productivity, but this is not the case where browsers and grazers are combined (Prins and Fritz 2008:191). Both sheep and cattle benefit from co-grazing in greater liveweight gains; due to differences in nitrogren loss in cattle and sheep urine the soil pH can be altered differently by each species (Esmail 1991). Increased nitrogen from urine and faeces can lead to a positive feedback mechanism whereby greater growth attracts herbivores back to the same location (Harrison and Bardgett 2008:205). Different combinations of livestock lead to differing changes in grazing composition (Prins and Fritz 2008:192).

Due to differences in plant preference sheep are more successful grazers on marginal heathland (Celaya *et al* 2007). Grazing of cattle and sheep examined on unenclosed lowland heath in northern Germany indicated that the cattle and sheep had mutually exclusive preferences, with cattle grazing the wet areas whilst sheep avoided them, and cattle avoided the dry low nutritive value areas that sheep preferred (Putfarken *et*

al 2008). However, species does not appear to have a differential effect where swards become damaged; general overgrazing is the most damaging aspect, although horses in addition create latrine areas (Gibson 1997). Sixteenth and 17th Century texts refer to the proportion of sheep to cattle being five or six sheep for each cow (Davis 2002:58), similar to the ratios for modern Livestock Units. Stocking rates can however vary dependent on the productivity of the land and time of year (Wiseman *et al* 1993:187).

Table 9: Pasturing domestic livestock

Pasture Use	
Sheep	
• Sheep graze closely (Seymour 2003:113). • Sheep will graze in woodland, but tend to seek out the areas which offer the greatest nutrient value rather than the greatest biomass (Garin *et al* 2000). • In-lamb ewes need more and better quality fodder in late gestation, when the lamb puts on most of its mass, and good pasture needs to be available after lambing (Goodwin 1979:84-5) • It is frequent practice to 'flush' ewes prior to tupping, providing them with greater nutrition (Fraser 1947:40; Henderson 1944:82-3). • Wethers kept purely for wool can survive on very poor land that cannot provide sufficient nutrition for breeding stock (Fraser 1947:64).	Sheep will choose more than one fodder source even if one high quality option is available (Parsons *et al* 1994). Foraging behaviour in deciduous forest on the Atlantic coast of the indicated that sheep will browse a wide range of species, but will do so to a limited degree, increasing browsing of new growth in spring and reliance on grasses over winter (Garin *et al* 2000). Sheep select between grazing different pastures, different plants on pastures and different parts of the plant. Sheep have preferences but these can be influenced by novelty (Parsons *et al* 1994:466,474-5). Sheep in Early Medieval Ireland were not regarded as being a hill animal; they were kept closer to home, and folded nearby at night, although they were occasionally grazed on common land further away. The law codes indicated that lambs should not be included in this practice until after August (Kelly 2000:68-9).
Goat	
• Goats will graze marginal land that is too steep or rough for other livestock (Bryce and Wagenaar 1985:94), but diet overlaps with sheep if present in larger numbers in the uplands or where browse is less available (Bullock 1985:430,432). • They can assist in reclamation and control of scrub and pernicious weeds, able to clear species such as blackberry and thistles (Halliday and Halliday 1988:73). • They will eat vegetation unsuitable for sheep and leave the grass (Seymour 2003:104), and actively seek browse even when higher quality grazing is available (Papachristou *et al* 2005:146), and consequently improve and reclaim pasture (Bullock 1985:431). • Goats thrive in deciduous woodland and on heather and gorse. Bracken, however, can cause internal bleeding (Salmon 1981:26).	Goats love tree bark and trimmings of elm, chestnut, willow, ash or apple, and damage hedges (Salmon 1981:56; Ross 1989:49). They are more effective browsers than sheep partly because of greater mobility and manoeuvrability of their muzzles enabling extracting leaves from between twigs and thorns (Papachristou *et al* 2005:142). They will actively seek a varied diet possibly to maintain rumen health and are capable of changing quickly from herbaceous to shrubby material, and are influenced by flavour (Morand-Fehr 2005:27). Feral goats have occurred in a number of locations in Scotland and the Western Isles in the last three hundred years, eking out a living on cliffs and other inaccessible places, avoiding wet ground (Watt and Fraser Darling 1937).

Cattle	
• Cattle generally graze longer grass, between 5 and 10cm high (Putfarken *et al* 2008:62). • Mixed pasture containing leguminous plants with higher protein content is best and retains nutrient quality as grasses mature. • Concentrating cattle on small areas ensures the grass is grazed right down (Smith Thomas 2005:30).	The relative qualities of pasture, the value of clover and the problems of overstocking were something that people were aware of in 9th Century Ireland, referring to 'a fewness of cattle in grass' as being better than plenty. Cattle, including free ranging animals in the New Forest avoided wet areas in the winter, generally grazing the higher quality forage (Hessle *et al* 2008; Putman *et al* 1987).
Pig	
• Grazing can provide a fair proportion of the diet (Allen 1910:55). • Rooting behaviour leads to destructive effects on grass. Recommended for grazing that is going to be reseeded (Bryce and Wagenaar 1985:97). • Rooting can be controlled with wire or a ring in the nose, and other materials could be utilised in the same way (Albarella *et al* 2007:306). • Mediterranean peasant farmers allow pigs to roam watched by a swineherd, grazing stubble, fallow and woodland (Barker 1985:35; Blake 1990:201).	Wild pigs do not form stable colonies in areas more than 10km from woodland (Choquenot and Ruscoe 2003). Pigs can be allowed to roam around and forage within the domestic area (Redding and Rosenberg 1998:68). Allowing a certain amount of rooting reduces boredom leading to aggression and harmful behaviours such as tail biting (Jensen *et al* 2008:271).
Horse	
• Not tidy grazers, they tend to overgraze some areas leaving the grass long elsewhere, giving a patchy effect. • They do best on short grass, so can be grazed alongside sheep and cattle, or after them in rotation (Frazer 1988:199; Houghton Brown and Powell-Smith 1984:165).	Horses in enclosed areas, unlike those in a free-ranging system, do not eat and defecate in the same areas, producing patches of ungrazed but well fertilised land (Lamoot *et al* 2004:106,116). New Forest horses show seasonality in their grazing, making use of browse, including gorse in the winter, and changing grazing when different plants come into growth (Putman *et al* 1987).

Table 10: Stocking and containing domestic livestock

Stocking Rate and containment	
Sheep	
• Fencing needs to be robust and 0.8-1.0m high, as sheep are renowned escapologists, especially rams, and ewes when lambs are first separated (Alderson 1988:117; Hart 1994:38). • Modern stocking rates to ensure a healthy grass sward are recommended as 12 sheep per hectare in summer (Pryor 1996:320; Seymour 2003:113), although 20 ewes plus lambs is possible (Wiseman *et al* 1993:193). • The absolute maximum for primitive sheep is 17 ewes (plus lambs) per hectare (Pryor 2006:106). • There are advantages to separating age cohorts; younger sheep may benefit from not having to compete with more experienced animals for grazing resources (Fraser 1947:60).	One sheep per acre was recommended in the late 18th Century (Davis 2002:52). The method of folding described by Fitzherbert seems to describe the dividing of the land parcel by 'stakes' which are moved every two to three days, but allow the sheep to move to the safety of the hedge in bad weather (1534). Population in feral Soay sheep has been shown to fluctuate due to winter mortality caused by starvation after years in which the population has increased due to abundant summer forage; higher mortality in lighter birth weight lambs occurred in line with the increase in population especially when it exceeded 2.2 animals per hectare (Clutton-Brock *et al* 1991; 1992).
Goat	

• Boundaries need to be high, and hedges may not contain them as there are few thorny bushes which a goat will not eat through (Bryce and Wagenaar 1985:95; Salmon 1981:32; Ross 1989:41). • Goats can be tethered but do not like high winds, rain, hot weather or flies, and will not eat trampled herbage. Consequently they need to be moved every two hours (Salmon 1981:31,34).	Traditionally goats have been kept in a number of ways; all take into account that they are active, agile and can jump onto walls and roofs. Tethering is problematic but enables utilisation of areas unsuitable for other stock (Bryce and Wagenaar 1985:95). Hard ground helps to keep hooves worn down, as does providing a large stone as a look out stand. Kids and goatlings benefit from the exercise of having things to climb on (Ross 1989:38,43,62). Because males can be fertile from 3-4 months of age they need to be separated from the rest of the herd (Salmon 1981:28,86). A feral population of 200-300 has existed on Rhum for probably 200 years. They naturally have hefted into five female led groups, which have home ranges that only partially overlap, and form 'foraging parties' of 5-6 animals. This feral population uses natural caves and beach overhangs (Dunbar and Shi 2008:447-449).
Cattle	
• Fencing needs to be robust enough to withstand their weight, and high enough to prevent trampling. It also needs to be solid to prevent them pushing their heads through and making holes (Smith Thomas 2005:14). • Good quality pasture can support four adult cattle per hectare in the growing season, whilst poor and weedy pasture as little as one cow for five hectares (Smith Thomas 2005: 14,142). • Stocking rates also vary in modern cattle breeds. Jersey cattle (average liveweight 356kg) can be stocked at 3.33/ha, Guernseys (AL 457kg), 2.5-3.0/ha and Fiesian/Holsteins (AL 560-660kg) 2.0-2.5/ha (Slater 1991:77). • Young animals being fattened for beef in the summer months can be stocked at rates up to 10/ha on good grass (Wiseman *et al* 1993:192).	Cattle can be very self sufficient as demonstrated in 'free range' systems, although they need observing and occasional intervention (Young 2003). Cattle can be tethered in order to make use of odd corners (Henderson 1944:161). This method has been observed by the author in various areas of Greece, utilising stubbles in fields that are not stock proofed.
Pig	
• Pigs and will damage fencing and gates, so fencing needs to be strong. • Maximum recommended stocking density is 20-24 pigs per hectare, (Goodwin 1973:121), 10 in an organic system (Blake 1990:200), reduced on problem soils and in bad weather (Seymour 2003:31). • Pigs prefer to live in groups (Seymour 2003:107). • Close penning of pigs can cause fighting and tail biting (Goodwin 1973:121,136; Bushby 1988:143,156). • Pigs need a damp area in order to wallow, which keeps them cool and prevents sunburn (Defra 2003:32).	Land needs to be well drained or it becomes a quagmire. On the European mainland, the density of pigs put out on pannage in the Middle Ages varied from 0.24/ha – 1.2ha (Vera 2000:124).
Horse	

• Ideal paddocks are not too steep, south-facing with shelter such as trees, or a wind break. Holes and rocks should be avoided as horses easily injure their legs. Well drained land avoids paddocks becoming muddy. • Two horses per hectare is recommended (Houghton Brown and Powell-Smith 1984: 162-3,165; Bryce and Wagenaar 1985:96).	Horses like company, and will break out of fencing if left alone (Frazer 1988:201). They should not be kept with pigs as they do not get along. Horses are often kept in gender groups to reduce aggression, but it appears that early experience of animals, space and management of feeding are more effective (Jørgensen *et al* 2009).

Rotational grazing can induce animals to consume vegetation that they would not initially choose, as forage becomes less available (Walker *et al* 1989). In the modern British context pasture is generally managed in terms of short term (<4 years) and long term (4+ years) leys, with short term leys used as a break crop in an arable rotation. Whilst large scale 'continuous grazing' can be employed, and require less in the way of boundaries, it is difficult to attain even grazing pressure (Frame 1992:188). ''Paddock grazing' uses small enclosures where the grass can be eaten down in a week. 'Creep grazing' is a variant that allows lambs first access to clean pasture (Figure 3). 'Strip grazing' allows animals to move across a field by moving a barrier, in modern systems generally an electric fence, but achievable with hurdles. Both methods ensure effective worm control (Salmon 1981:51; Wiseman *et al* 1993:188). Rotation of arable after grazing was probably developed reasonably early (Fenton 1981:215). Medieval English open fields were grazed after arable cropping and on the sandy soils of medieval western Jutland, small unfenced fields were operated under a long term grazed fallow period of three to six years. Moors, commons, and other pastures were also important (Poulsen 1997:119). Woodland also provides additional grazing for cattle and pigs, but also produces leaf fodder, and wood for fencing (Reynolds 1987:44-49).

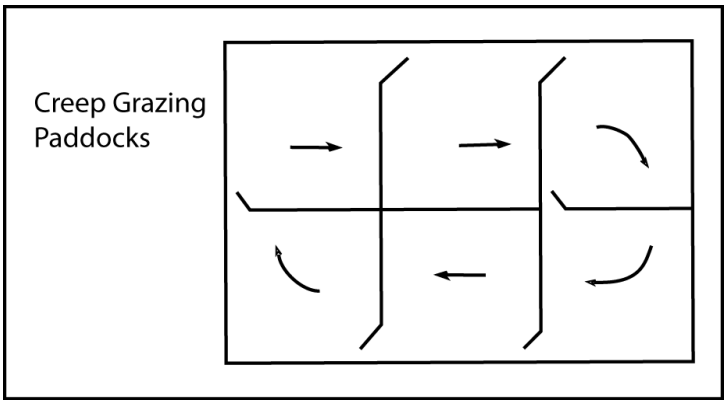

Figure 3: Creep grazing system using small paddocks (After Goodwin 1979).

Grazing of wetlands can be done both with and without modification of the landscape. The inevitable fact is, however, that the rich growth that results from copious water and regularly replenished nutrients is countered by the duration of time that land can be accessed without detriment to the sward, soil structure and the livestock. Ditches can provide drainage which allows land to be accessed for longer. In addition, better drained soils are warmer, more aerated and allow root development (Cook 1999:15-6; Dent 1999:73). The degree to which this is utilised depends on soil type (Cook 1999:18) the availability and quality of grazing compared to the additional investment of labour in construction and maintenance. Arable cultivation is possible on tidal marshes as long as the crops are not inundated for long periods, and drainage via ditches was effectively achieved in Somerset in the Romano-British period (Rippon 1999:103,109). Water meadows in their strictest sense are areas of grassland where the quality and quantity of herbage has been deliberately manipulated by water management (Cutting and Cummings 1999:157). However, flood meadows exist where the land is lowlying enough for seasonal inundation. Soil and nutrients supply a regular top dressing where there is a low energy flow of water allowing its deposition. This encourages a rich sward that can be grazed and mown, and can be achieved by damming watercourses. Catchwork systems of meadows were utilised on Exmoor in the 19th Century AD, consisting of dykes and channels diverting water from springs and streams; more complex systems of dykes, sluices and channels became one of the most widespread 'improvements' in Wessex from the early 17th Century (Cutting and Cummings 1999:158-9; Bettey 1999).

2.2.3 Foddering

Foddering covers a range of methods of spreading the utilisation of foods throughout the year, smoothing the effects of summer glut with winter famine, and includes a wide range of feedstuffs. It has been assumed that medieval farming was constrained by lack of winter fodder, but medieval texts indicate that it was available. Hay is mentioned, but arable by-products receive most mention (Forbes 1998:29), although most British references to overwinter foddering prior to the 18th Century relate to traction animals. Pre-industrial livestock farming in Britain was not therefore necessarily chronically constrained, but integrated with arable cropping, utilising

residues, whilst arable was in turn dependent on the input of animal manures (Forbes 1998:30, *contra* Williamson 1998:12), which is discussed further below. Livestock were normally only milked in the summer months when feed was readily available. Lack of milk production over winter would not be problematic in an economy that focussed on butter and cheese production as these could be stored (Forbes 1998:28,30). Winter culling of animals has been seen as a result of lack of winter fodder. Whilst culling purely for this purpose may not have been widely practised, a 13thC AD cartulary of Gloucester Abbey instructed that over-wintering of animals on hay should not be carried out where they were 'useless and infertile' (Lake 1989:16). Similar culling decisions form the basis of removing animals from flocks and herds now, and were probably widespread in the past.

The simplest method of foddering is allowing autumn and winter 'aftermath' grazing of arable stubble left to naturally regenerate (Forbes 1998:30). In the early 20th Century in western England, sheep were kept despite lack of inherent profitability, purely because they utilised stubbles provided second grazing after cattle, and manured the land (Henderson 1944:79,81). Modern 'zero grazing' involves cutting fodder and carrying it to housed or penned animals. It is labour intensive, but far less fodder is wasted so more can be produced by a smaller area (Salmon 1981:51). Classification between crops as food or fodder is not always straightforward. In modern farming whilst many arable crops are produced for human consumption, much is utilised as animal feed dependent on quantity and quality. Ethnographic observations in various parts of Greece, indicated that utilisation could change between and within communities at different times of year, and processing of crops may not be detectably different (Jones 1998:96).

Hay is a practical option to utilise extensive spring grass growth. It is normally possible to obtain a tonne per hectare (Seymour 2003:168). The quality of hay is not only related to the quality of the grass but the conditions under which it has been made and stored; the best hay is wind rather than sun-dried but must be kept dry (Bryce and Wagenaar 1985:20; Fitzherbert 1534; Street 1942:94). When cutting hay, it has the highest food value when the grass has come to a head and just before the pollen appears. It needs to be cut when dry, and turned, and although making good hay

requires experience, it can be achieved in small quantities using simple wood tripods (Salmon 1981:51). Ensiling grass to make silage is a method of harvesting and storing grass without the problem of drying hay. The method is to seal wilted grass into a container where air can be excluded, and is generally made in a pit, in modern times lined and sealed with plastic (Bryce and Wagenaar 1985:21). It can be produced in smaller quantities as evidenced by bagged baled silage (Wiseman *et al* 1993:202,210). It utilises the acids produced by fermentation, but care has to be taken to produce the correct composition; wilting the grass when dry encourages a higher temperature to be obtained and encourages production of lactic acid (Slater 1991:102-3).

Silage can also be made from cereals harvested green (Wiseman *et al* 1993:199). Silage has been manufactured for centuries in southern Britain and Europe. It is mentioned in the will of David Grant, of East Lulworth, Dorset in 1730 (Dorset Record Office), and by the end of the 19th Century competitions were being run for the best quality silage (Frame 1992:209). After 1950 silage took over from hay making due to mechanisation and greater understanding of the fermentation process. Before that date, fresh grass was ensiled straight from the field ('T Mannetje 2002:205). Silage can be highly palatable; horses will choose it over hay the majority of the time (Müller and Udén 2007), and it may have an earlier inception than hitherto realised.

Animals will eat a wide range of plants. Ruminants display preferences for plants that they are exposed to early in life (Villalba *et al* 2006:191,201). Use of leafy fodder was common all over Europe either harvested in autumn and stored or utilised in early spring (Rasmussen 1993:498; Haas *et al* 1998:81). In Ireland there is little evidence of hay-making until the arrival of the Normans but holy and ivy were cut as winter fodder (Kelly 2000:46). It occurred in 19th Century Iceland, particularly to safeguard the fodder provision from infield areas and in spring before grass growth (Amorosi *et al* 1998:46). Condensed tannins in a range of browse plants have a generally deleterious effect on digestion and performance, but have been noted to have a positive effect on parasite load in sheep and goats (Waghorn 2008:132-3). Additional choices in utilising the available fodder may be more difficult to identify as they relate to taste preferences; dairy products' flavour can be changed by selectivity in grazing particular plants (e.g. Carpino *et al* 2003; De Noni and Battelli 2008). The way that people perceive meat

freshness and palatability can be based on brightness and colour, and varies depending on cultural background. Numerous studies show that ruminant diet changes the properties of meat, including changing colour, fat content and flavour; the tannin content of fodder (and hence the amount of shrubby material and browse) is a major factor; sheep fed higher tannin content feed have paler meat (Vasta *et al* 2008:227,229).

2.2.4 Penning, handling and housing

Containing animals has a number of benefits, although the primary one is the ability to manage forage as discussed above. However, the ability to sort and separate species and cohorts of animals can also be beneficial. Mixing and rearranging groups of sheep, cattle and pigs causes stress and aggression as they determine a new hierarchy (Andersen *et al* 2008:133), whilst goats are particularly hierarchical when housed in groups (Aschwanden *et al* 2009:171-2). Pens and handling equipment can assist in managing these behaviours. The form and layout of fields will be discussed in relation to their identification in the next chapter, but enclosures can occur in any animal husbandry system, and their form reflects their utilisation. Issues of handling and housing livestock are laid out in Tables 11 and 12.

Table 11: Handling domestic livestock

Handling animals	
Sheep	
• management, lambing, milking and shearing. • Tightly penned sheep are easier to manage (Goodwin 1979:105). • Modern sheep need c0.4m² of standing room (100 ewes in an area 6x7m), and post and rail fencing is suitable (Goodwin 1979:158-160). • Races are no more than *c*1.8m wide (*c*0.45m wide for smaller types of modern sheep) approached by a Y shaped crush, often at an angle to the race enabling animals to be driven in singly, without turning around (Goodwin 1979:161). • 'Primitive' sheep apparently cannot be worked with a dog, but this has been challenged (Pryor 2006: 98-99), although recent dog use in Europe has varied, possibly relating more to guarding than herding (Barker 1985:32).	Handling sheep is a frequent necessity, for health. Separating sheep into cohorts dependent on breeding status and age has occurred since at least the 18th Century (Davis 2002:51). Castration of sheep to increase wool production is attested in literature as early as the 13th Century (Davis 2002:53). Penned sheep panic if given too much space, so catching pens are often subdivided with additional gates and hurdles, which can be progressively reduced to reflect the number of animals. Catching pens are often round. Sheep are reluctant to enter spaces which they cannot see out of; they will move more readily to a gate or hurdle that they can see through (Bryce and Wagenaar 1985:34). Small flocks can share handling equipment with other livestock. Handling pens should be located with access to where sheep are gathered and water should be available, whilst gentle slopes give drainage and some shelter is desirable (Hart 1994:89). Races can be utilised in two ways, as a narrow drafting race with a sorting gate at one end, or a slightly wider

	working race in which a person can stand and handle each animal as it passes; small decoy pens, holding an individual sheep are used to encourage the animals to enter the system (Bryce and Wagenaar 1985:35).
Goat	
• Goats need to be regularly handled for similar reasons as sheep; • They will walk easily when driven or led, following a leafy branch, and respond to being called. • When being milked they can be tethered but are equally kept still by being fed. • Regularity in milking is more important than equal intervals of 12 hours (Salmon 1981:37,63,66). • Pens make handling and monitoring feeding easier (Ross 1989:26,28,38).	Grooming should be carried out daily. This removes fleas and lice, cleans the skin and makes the goats less attractive to parasites, and stimulates circulation (Ross 1989:39).
Cattle	
• Cattle need frequent handling for health care, calving, and milking • Cattle will follow and can be handled in the field; animals that lead easily tend to provide more milk (Henderson 1944:71). • Rope halters are a simple and effective method for moving small numbers (Manolson *et al* 1988:172). • It ordinarily takes two people to catch calves, one herding them along a fence, the second handling panels and ropes (Smith Thomas 2005:13). • Halters, tethers or crushes need to be robust and prevent movement (Bryce and Wagenaar 1985:56). A crush or pen can be achieved with a gate swinging against a wall. • Races and pens are generally arranged so that people do not need to be in them with the animals (Waiblinger *et al* 2003). No minimum sizes appear to be available. For sorting purposes, pens need to be side by side. • If penning for a longer time, the cattle need to be able to move around, and soft damp ground avoided as they need to keep a good footing (Smith Thomas 2005:9-10). • Area allowed in pens for modern dairy cattle consists of 4.2m² for lying and 2.0m² for 'loafing' (Slater 1991:47)	Increased interaction with cattle has been demonstrated to decrease nervousness (Waiblinger *et al* 2003). '*Handling cattle always involves a risk of injury from crushing, kicking, butting or goring. The risk is increased if the work involves animals that have not been handled frequently, such as those from hills or moorland, sucklers or newly calved cattle*' (HSE 2006:1). A regular routine of handling bulls daily with rewards of food rather than coercion will keep them docile (Henderson 1944:73-4). Gelding animals at a young age was appreciated to be less risky from at least the 16th Century, whilst the change in body shape was also appreciated (Davis 2002:49). Early Irish texts refer to milking morning and evening which could take place away from the farmstead during the summer months but often in a small enclosure within the farmyard where the cows could be restrained (Kelly 2000:40-1). They also refer to the necessity of the proximity of the calf for the letting down of milk (Kelly 2000:37-9; McCormick 1992).
Pig	
• Pigs need handling for health care and at farrowing. • Small pigs can be picked up by the shoulders. • Adults can be moved around by walking utilising a board, to prevent the pig looking	Unacquainted pigs of any status will fight (Fredriksen *et al* 2008:265). Entire male pigs are prone to aggression (Fredriksen *et al* 2008:259). This is reduced by castration, but can also be managed by keeping male pigs in sibling groups (Frederiksen *et al* 2008:264). In intensive modern systems pigs can

from side to side, and a 'bat' to promote walking. • Where animals have to be moved frequently, races are helpful. • It is advantageous to confine sows with young litters to hurdled pens for the first week of life, to ensure that piglets don't roam too far and enable checks that the sow is milking well. • As an alternative, sows can be tethered. • Young males need to be penned for castration (Goodwin 1973:112,124). • Corsican semi-feral pigs are rounded up into enclosures, which are constructed of stone (Alberella *et al* 2007:302).	become aggressive when housed and indulge in tail biting (often dealt with by tail-docking and clipping the incisors), which can however be reduced with the provision of straw to root in or objects to play with (Zonderland *et al* 2008:270).
Horse	
• Horses need regular handling for health care, occasionally when foaling, and to enable their docility when used in riding or traction. • Horses are generally tethered for handling and can be taught to stand (Houghton Brown and Powell-Smith 1984).	Grooming the horse promotes health by removing dirt that might harbour infective disease, removes a variety of external parasites, and improves muscle and skin tone and circulation. Daily grooming also builds the relationship between the horse and the handler (Houghton Brown and Powell-Smith 1984:147). The easiest way to break horses is to accustom them to being handled and led occasionally from a foal. They are ordinarily ready for breaking at two and a half to three years old, and the process is one of overcoming the animal's nervousness in gradual stages (Frazer 1988:199,204,208-10).

Table 12: Housing domestic livestock

Housing	
Sheep	
• Most sheep need no housing beyond natural shelter from rocks and trees, even in winter (Alderson 1988:116; Goodwin 1979:40,43). • Housing enables shepherds greater control, particularly during lambing, reducing lambing mortality considerably, and protects newborns (Alderson 1988:116). • Housing may increase a ewe's working life, but if animals are housed, foot problems can result. (Goodwin 1979:85,169,172). • Sheep in lowland Britain have generally been housed temporarily in buildings used for other purposes, or by using stakes and hurdles (Lake 1989:31).	Medieval sources indicate that sheep should only be housed in bad weather, (Forbes 1998:28). However, when ewes go into labour they will get away from the flock and make a bed. A number of complications can occur that need immediate assistance, such as cleaning membrane from the mouth and nose. Orphans or rejected lambs can be fostered by confusing a ewe's sense of smell or using the skin of the dead lamb, and penning to ensure that the adoption works (Goodwin 1979:91-2,94). Fitzherbert recommends both of these methods advising a space made of boards about a yard wide (1534). Warming lambs can remedy exhaustion, but the lamb needs to be penned close with the mother (Fraser 1947: 45,48,51-2); ewes they can imprint on the wrong lamb (Bryce and Wagenaar 1985:49), so pens or housing are useful for the management. Spaces need to be sufficient in size for the shepherd to work. Effective ventilation is essential as sheep are particularly susceptible to respiratory diseases (Defra 2002:19). Draught reduction is the principal need, requiring

	walls of at least 1.4m, whilst pens need to be tall enough to stop sheep trying to scramble over them, 1.5m x 1.5m being standard for five sheep (Hart 1994:48,84,87).
Goat	
• Goats are less winter hardy than other livestock (Seymour 2003:105); their hair has poor waterproof qualities, and they have no undercoat (Bryce and Wagenaar 1985:94; van Wijngaarden-Bakker 1998:177). • In Britain, they cannot survive without housing (Blake 1990:196). • Feral goats find shelter in caves, overhangs or abandoned huts (Salmon 1981:29).	If goats get wet they can develop pneumonia. In the Mediterranean goats tend to be loose housed, and in northern Europe penned (Ross 1989:26,28,38). Pens are generally five feet square. Larger areas increase the amount of bedding required, whilst smaller, they are difficult to work in and the goats are unable to move freely (Salmon 1981:22-3). Housing needs to be robust, as goats stand up on ledges and gnaw wood; wood with the bark still on is recommended. Housed goats need daily exercise, so yards can be attached (Ross 1989:36). Draughty, cold housing means more food is consumed keeping warm at the expense of milk yield. Light levels affect milk production, although flies are deterred by dark places Mucking out should not be too frequent with a full change every 4-6 weeks. (Salmon 1981:108), as a build up is insulating and comfortable (Ross 1989:38).
Cattle	
• Most of the time cattle do not need shelter, although calves are more likely to need it than adults (Smith Thomas 2005:16). • Outdoor reared calves are generally healthier but housing is needed for births in cold weather and can prevent some other problems, such as 'mis-mothering' where the animal fails to suckle its mother and misses out on colostrum (Blowey 1988:15). • Cattle need some form of windbreak or shelter in severe or exposed climates • Woodland provides shade, but buildings have to be kept clean. • Cattle are more likely to suffer from disease if housed but are more productive and need less food; housing also prevents the poaching of pasture in winter (Lake 1989:33). • Manure heaps should be sited as far away as practical from the areas in which cattle are stalled (Manolson *et al* 1988:177,183).	Low temperatures are associated with higher calf mortality; they are especially susceptible to rapid changes of temperature in the first few days of life due to a lack of ability to regulate, and will seek out warmth (Borderas *et al* 2009). Housing for calving and calves is useful, but needs to be well ventilated to avoid an overly warm damp atmosphere that encourages disease. Flies are an irritation and also spread diseases such as summer mastitis. Shelter in the middle of the day can reduce the problem. Shelter from the sun ensures that overheating is reduced which can have a range of negative physiological effects including reduction in fertility (Schütz *et al* 2009:29); cattle will seek out shade that provides the greatest protection from solar radiation (Tucker *et al* 2008). However, modern housed cattle are more prone to hoof and foot disorders and lameness (Olmos *et al* 2009). Shelter sheds and loose boxes from the 18th century onward are indicative of fattening young animals for meat (Lake 1989:34-5).
Pig	
• Adult pigs need little shelter, but very young animals are extremely vulnerable to cold. Farrowing requires shelter. Pigs, like sheep can be revived by prompt warming (Allen 1910:38) • Arrangement of farrowing space is crucial. Long straw can cause piglets to get tangled up, and sows can tread on or crush their piglets (Burri *et al* 2009), especially in large	Another cause of death in neonatal piglets is savaging by the sow (Chen *et al* 2008:239). Pigs have, since the medieval period at least, been largely housed in Britain, and have been kept close to the home in a variety of structures, including spaces built into walls.

litters (Lensink *et al* 2009:151-2). The first 48-72 hours of life are the most hazardous (Cronin and Smith 1992). • Bedding can be provided by straw, chaff, bracken, peat moss, sawdust or wood shavings, cleaned out on a daily and weekly cycle. (Goodwin 1973:96-7,101-102,127,133-4). • Conception rates improve if sows are unstressed, and housing after mating is recommended. • Copulation in pigs can be a lengthy and tiring so terraces and slopes or crates are often utilised. • Housing should be free from damp, warm, well ventilated, with room to move. Damp causes a number of health problems. • Housing provides shelter from the sun. Pigs are acutely susceptible to heat stress (Defra 2003:16).	
Horse	
• Horses are hardy. They rarely suffer from cold, if they keep their long winter coat, but need some form of shelter. • Stabling provides safety, and the stabled horse is easier to control. They need plenty of fresh air as they are prone to respiratory ailments (Frazer 1988:204; Houghton Brown and Powell-Smith 1984:7,140,147; National Equine Welfare Council 2005). • Standard modern open boxes are 3.5m square, but various methods of stalling have been used in the past (Frazer 1988:204);	Clipping the coat ensures working horses do not overheat, but necessitates housing. Horses at peak fitness do not have a protective layer of body fat, and if they are groomed, the natural protective oils in the coat are removed. Good bedding keeps out draughts and damp and provides warmth (Houghton Brown and Powell-Smith 1984:143). Buildings need to be high enough to enable the animal to stand up and move around (National Equine Welfare Council 2005).

Penning, especially at night is useful when predation by large carnivores may occur. Enclosure of animals at night is important to the Maasai for this reason (Shahack-Gross *et al* 2003). Recent examination of the rate of predation of sheep in the French Alps, following re-colonisation by wolves, indicates that, although wolves tend to live at low population densities, they conflict with extensive livestock rearing. The majority of attacks take place at night (Espuno *et al* 2004:1197-8). However, in recent studies in North America, wolves chose to predate mainly wild species rather than livestock (Chavez and Gese 2005). The use of guard dogs and gathering and confining sheep can be efficacious in reducing the number of successful attacks on sheep, being most successful when combined (Espuno *et al* 2004:1203).

Handling animals occurs for a variety of reasons, be it general movement of animals from one pasture to another, assistance with reproduction, or veterinary reasons. Animals need to be handled in order to milk them, which is not an entirely straight forward process requiring knowledge and methods of restraint (Ryan 2002:101-103). Handling animals has a range of benefits from ease of husbandry to increased productivity in meat and milk production (Windschnurer *et al* 2009:118). Some methods utilise halters and tethering, but the majority rely on fencing of one description or another to hold stock in one place, smaller pens for subdividing flocks and herds, with various arrangements to immobilise individual animals for examination. Handling features are not only ubiquitous but vary by location and over time and can be shown to be of long currency in a recognisable form. Fitzherbert (1534) describes the process in lowland England of sorting and examining sheep using an arrangement of pens, which is virtually identical to modern methods:

> '*Than thou grasier, that hast many shepe in thy pastures, it is convenient for the, to have a shepefolde made with a good hedge or a pale (fence), the whiche wyll receyue all thy shepe easyly that goo in one pasture, sette between two of thy pastures, in a drye place, and adioynyng to the ende of the same, make an other lyttell folde, that wyll receyue lxxxx shepe or moo, and bothe those foldes must haue eyther of them a gate into eyther pasture, and at the ende of that folde make an other lyttell folde that wyll receyue xl shepe or mo, and betwene euery folde a gate. And whan the shepe are in the grate folde, let xl of them or there about, come into the myddle folde, and steke the gate. And than let the shepeherde turne them, and loke them on euery side, and if he se or fynde any shepe, that nedeth any helpynge or mendinge for any cause, lette the shepeherde take the shepe with his hoke, and put hym in the lyttell folde. And whan he hath tyken any that nedeth any mendyng, than put the other into whether pasture he will, and let in as many out of the greate folde, and take those, that need any handling, and put them into the lyttell folde. And thus peruse them all tyll he haue done, and than let the shepeherde go belte, grese and handel all those that he has drawen, and than shall not the great flocke be taryed or kepte from theyr meate: and as he hath mended them, to put them into theyr pasture*.'

This passage describes a method of configuring pens the process by which sheep are 'turned', a procedure that allows the inspection of the animal for parasites and injuries and checking, cleaning and trimming of the feet. The process is entirely recognisable to

anyone who has handled sheep. A more modern configuration including a drafting race for sorting animals is shown in Figure 4.

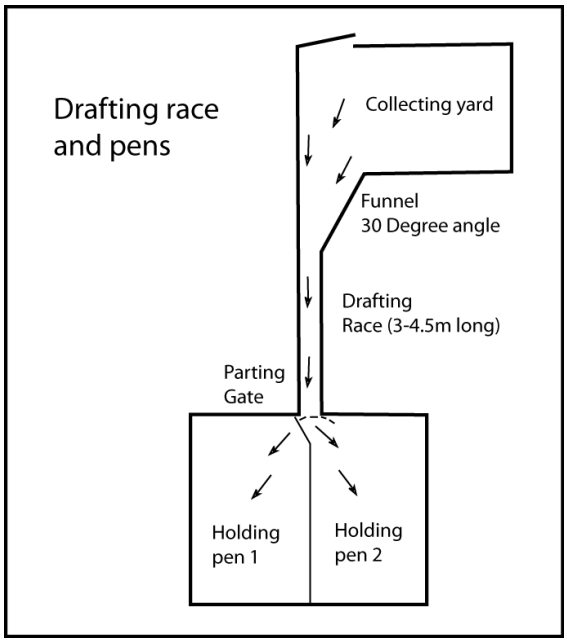

Figure 4: Drafting race for sorting sheep (After Goodwin 1979).

Structures may be permanent or temporary, even in more 'settled' livestock raising systems, especially if a seasonal activity such as lambing is involved. In lowland England at the beginning of the 20th Century,

'*The lambing pen is made of hurdles, but the hurdles are placed double with a packing of straw between them so as to form a windproof wall....more hurdles are erected to form a sloping roof to the walls making them into long sheds. This roof is then thatched with straw to shoot off the rain*' (Street 1942:38) (Figure 5).

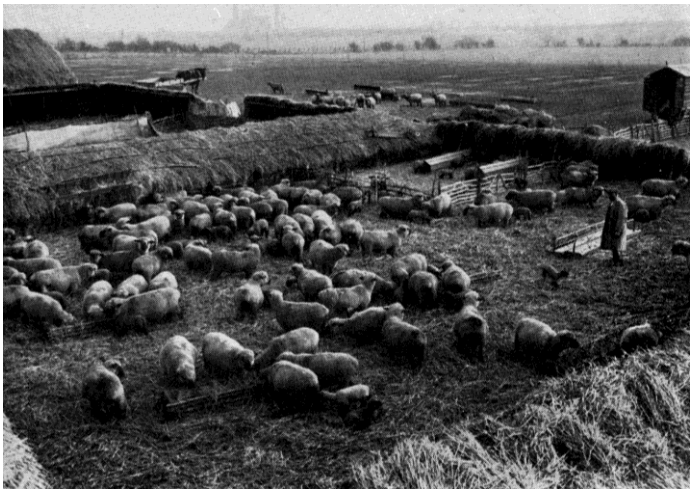

Figure 5: Temporary lowland lambing pen, southern Britain 1930s (Street 1942:42).

Whilst not all livestock management systems require the complexity described for the lowland British farm of the 19th Century,

> *'Farms of ten or twenty acres….will require cow sheds, of length suited to the number of cows and calves to be kept, ……. a dairy room, a little barn, a tool house, root house; and pig sties with paved yards, divided from each other, for store and fat pigs, and for brood sows and their young ones*' (Doyle 1870:50-1),

some form of shelter or housing is a normal feature of most livestock systems. Cattle will seek out shelter in hot or cold weather, utilising natural shelter. Use of a wider area can therefore be encouraged by provision of shelter (Bailey 2005:111). Housing is particularly pertinent when considering lambing and calving. A number of ethnographic observations have been made of the way in which pastoralists deal with lack of mother-offspring imprintation and fostering. Herders assist with births, ensuring that ewes and lambs learn to recognise each other, before temporarily separating the lambs from the grazing herd to prevent injury by other adults. Three types of stratagems have been recorded ethnographically from as far afield as southern Europe, the Middle and Far East and Siberia. These are penning the ewe and lamb in a small enclosure until the ewe allows the lamb to suckle; blocking the ability of the ewe to smell the lamb and holding the animals together; and deception of the mother with the scent of the original offspring often using the skin of the lamb or its urine (Tani 2002:116). Buildings can be multi-purpose, and accommodate these activities. Post-medieval barns in Britain were used primarily for storage of arable crops and threshing over winter, but they were also used for fodder storage and included areas for housing cattle and horses over winter as well as shearing when empty in spring (Lake 1989:23). Specific housing for cattle in medieval and post-medieval Britain focussed on the housing of plough oxen, with references to the oxherd's duties of feeding and watering and mucking out, as early as the 11th Century AD (Lake 1989:27).

The general assumption is that in northern Europe the pig was a forest dwelling animal until the medieval period. Herding pigs in a semi-feral state occurs in Sardinia and Corsica (Albarella *et al* 2007). However, the situation may be more complex. Decline in

pig numbers and changes in pig body size at Medieval Dudley Castle may relate to the loss of woodland, leading to more sty pigs being kept, enabling greater control of breeding and feeding. This explains increased body size and greater numbers of neonatal pigs (Thomas 2006:22-23). Pigs in other Late Medieval contexts, when compared with earlier faunal assemblages, have greater size, a different culling pattern, changes to the expression of dental enamel hypoplasias and isotopic indications of increased consumption of animal proteins. This has been equated with loss of woodland. However, one assemblage with the features of the earlier husbandry regime was from an area that was already deforested (Ervynck *et al* 2007). In early medieval Ireland, the pigs of a number of owners under the care of a single swineherd, were taken into woodland to forage, but were normally returned to sties at night (Kelly 2000:80). Sty pigs were kept in Roman Europe (Barker 1985:35) and larger animals at Winchester, compared with those at Owslebury, in the Romano-British period may suggest sty-kept animals (Maltby 2010). Small herds of pigs were kept around farms in Roman Italy and fed on scraps and refuse (MacKinnon 2006:54). Modern animals spend the spring and summer months at pasture, but need housing within it (Allen 1910:56). A boar's housing in the early 20th Century was advised to consist of an open fronted shed, an exercise yard with access onto a paddock or orchard (Allen 1910). Dental microwear patterns at an Iron Age/Romano-British site at Elms Farm compared to modern examples indicate that, at least in the weeks before slaughter, the animals were eating a soft-textured diet and had no access to rooting. Similar to stall-fed animals, this implies that even if they were allowed to root in woodland in autumn, this was not the method of maintenance year round (Wilkie *et al* 2007:250,253).

2.2.5 Timescales

The routine work of caring for livestock is unlikely to have changed at a fundamental level. These tasks divide into daily, weekly, monthly or seasonal tasks (Table 13). The proximity of animals and people are affected by the various needs to handle animals. Some regular tasks can be done by individuals or small numbers of people, whereas other tasks need a group to handle them. The arrangement of the landscape, and proximity of housing for people, will therefore reflect the choices of species, strategy and methods employed.

Table 13: Routine example tasks associated with domestic livestock.

Daily	Weekly	Monthly	Seasonal
Feeding	Moving between paddocks	Hoof paring, cleaning feet (Sheep, horse)	Breeding
Watering	Fencing alterations	Cleaning out deep litter beds	Lambing/calving
Checking condition	Grass management	Managing muck heaps	Sorting cohorts by age/sex
Putting housed animals out to pasture	Checking condition		Castration
Milking and dairy work			Exchanging animals
Grooming (horse)			Culling
Mucking out			Repairs to housing/handling structures

2.3 The choice: pastoral farming strategies

''*Having herds' is central to the ideology of pastoral peoples*' (Robertshaw and Collet 1983:73).

'Pastoralism' relies on production from domestic herds, and generally involves the movement of herds to pasture (Dyson-Hudson and Dyson-Hudson 1980). However, this subsistence based definition has been challenged. In East Africa, arable crop production or trading for crops amongst people who regard themselves as pastoralists is frequent. It is rather suggested that anthropologically the definition rests on a 'cultural preoccupation' with livestock (Roberstshaw and Collett 1983:73). Pastoralism has been understood in various ways so the term 'pastoral farming' is to be preferred as it can manifest itself in a number of forms. Broadly, these can be categorised as nomadic/transhumant, extensive, and intensive systems, but combinations and gradations occur. Each has a differing relationship with arable cultivation, and can occur at different scales. For example a huge range of possible medieval English farming systems and strategies has been noted (Campbell 1995; Campbell *et al* 1996:143). Fundamentally, pastoral strategies revolve around maintenance of pasture, best achieved by grazing with the correct stocking density. The stocking density varies depending on the livestock species, grassland ecology and the time of year. Grass growth is particularly seasonally variable. If sufficient animals are available to consume the spring flush of growth, then alternative sources of fodder need to be found later in the year (Lewthwaite 1981:63), or the grass cut and stored. In addition extensive,

transhumant and intensive practices co-exist in certain circumstances. This can be a method of spreading risk, utilising various categories of land.

Different species require different strategies, and choices between species may be influenced by the practical and social feasibility of the strategies available. Differing systems have different requirements for labour inputs and organisation. For example, in purely practical terms of conversion of plant matter to meat, the pig is the most efficient option. However, sheep are a very efficient converter of plant matter to dung and can maintain arable cultivation (Lewthwaite 1981:61). Specialist pastoral practices arise as a response to specific conditions, and the prospects for sustainability. Sustainability in modern agricultural systems is defined as the value of the outputs exceeding that of the inputs, affording opportunities to the next generation equal or greater in value to those currently enjoyed (Glendinning *et al* 2009). This, however, depends on our very particular view of value.

2.3.1 Nomadism and Transhumance

'*the over-riding feature of all natural pasture...is its extreme seasonality*' (Fraser 1947:82).

Nomadic pastoralists utilise the changing availability of fodder by constantly moving their herds and flocks to the next available pasture. The ephemerality of settlement and stock handling features is variable. Another response to the problem of fluctuating grazing availability is transhumance, that is, the accompanied seasonal movement of stock from one area to another, often from the lowland to the uplands in summer, from a permanent settlement. This has been widely practised in much of the Middle East Mediterranean, the Balkans and Turkey, continuing into the modern era. The methods employed are frequently similar but allow marked differences in social arrangement between groups (Chang and Tourtelotte 1993:249-252; Rosen 1988). In the Campidano, Corsica it involved limited movement of population to overcome lack of fodder in late spring and early autumn (Lewthwaite 1981:60). In some cases the social element outlives the practicality. Greek Koutsovlach people move between lowland and upland villages regardless of whether they now have direct involvement in livestock husbandry (Chang and Tourtelotte 1993:252). Both the mountain and

lowland villages are permanent, as is ownership of mountain summer and lowland winter pasture (Halstead 1996:22-23). In many transhumant regimes, the use of lowland pastures accounts for 6-9 months of the year, covering the part of the year when it is hardest to maintain grazing supply (Lewthwaite 1981:60). Greek Sarakatsani, herd sheep, less frequently goats, and use horses and mules for transport. Milk and cheese were traded for flour, wool sold, and dung utilised by lowland farmers who rented them fallow land for winter grazing (Chang and Tourtelotte 1993:253).

Sheep do not necessarily need supervison at all times, particularly after lambing. In some cases, very few people need to be involved in stock movements. Corsican flocks have a high degree of territorial familiarity enabling them to be left unattended over summer (Lewthwaite 1981:63). Vlach herders have much larger flocks than village based herds, and they utilise dogs and goats as guide animals. Most herders cull most males under the age of 6 months (Chang and Tourtelotte 1993:255). There is some evidence that variations on these practices have occurred in the British Isles in the past. Early Medieval Irish texts indicate that in summer cattle were taken to uninhabited land away from the farm, on the hills, or land that was waterlogged in winter. However, even though accompanied by a cowherd, they were folded at night in a pen by a house or hut for the cowherd (Kelly 2000: 44-45). Wintering sheep on low ground is a customary practice in upland Britain, leaving the hills in October and returning in April. Moving animals need not involve the movement of people. The death rate is reduced, grazing preserved, and it is not necessarily the entire flock that is moved. Ewes remain on the hills while ewe hoggs (young animals) are moved to lower ground, effectively doubling the carrying capacity of the upland grazing (Frazer 1947:59). This practice indicates that there are considerable similarities between transhumant and extensive sedentary systems.

2.3.2 Extensive pastoral farming

'*Stocking is reckoned, not in so many sheep to an acre, but by so many acres to a sheep*' (Fraser 1947:99).

Extensive pastoral systems are characterised by controlled grazing of livestock at low stocking densities. Animals are either allowed free rein on common grazing or utilise

boundaries for management of grazing, occupying large areas of land. Whilst there may be some integration with arable cultivation, this is normally on a small and localised scale. Extensive cultivation and animal husbandry are complementary as both involve larger areas of land, infrequent cropping or less careful management (Bogaard 2005:179). In modern British and European Union agriculture, there is a policy preference for extensive systems, encouraged by subsidy regimes. Extensive systems are seen as more sustainable, whereas intensive systems are environmentally damaging and frequently regarded in pejorative terms (Defra 2001). The carrying capacity of poorer land is reduced by the grass species it will support, and extensive grazing is a frequent characteristic of upland areas. Smaller ruminants are better adapted to these kinds of conditions due to their selectivity in grazing and utilisation of browse, and in modern Europe, there is a positive correlation between the peripherality of an area and high proportions of sheep and goats. These abilities vary in modern breeds (Bertaglia *et al* 2007:658), and it may be that local populations of animals were adapted similarly in the past.

Extensive modern British hill systems utilise a combination of 'inbye' land, 'outfields' and common grazing. Grass pasture reaches its maximum growth in early summer and its minimum in late winter, which is more acute in upland areas. Grazing is needed at the height of this growth, and allowed to recover during the autumn. In upland Britain and Europe, the higher grazing is utilised in the summer whilst enclosed land produced an arable crop, and animals returned to the stubbles once the crop was harvested (Fraser 1947:84). The modern British sheep industry is focussed on meat production, with wool of secondary importance. Production is nationally stratified, with pure breed hill flocks providing pure and cross bred hoggetts and draft ewes to marginal and lowland farms for fattening on to slaughter; breeding animals move more than those destined for meat production (Goodwin 1973:34-35; Carlyle 1978). This commodified system illustrates the strategies for moving livestock on the hoof between differing but related exploitation systems.

Just as the number of animals per hectare is low, so is labour input. Boundaries are utilised for control of livestock allowing less human presence. Where boundaries are

not utilised, other strategies are employed that have commonality with nomadic or transhumant practices, the difference being the sedentary nature of the practitioners. Sheep in particular will 'heft' to an area. This is a learned behaviour, passed from ewe to lamb over succeeding generations. Lambs graze with their mothers and are instilled with knowledge of optimal grazing and shelter throughout the year. There are environmental, animal welfare and supplementary feeding advantages to allowing sheep to follow their own grazing preferences (Defra u.d.). Extensive sheep husbandry in Europe has however been shown to be the most vulnerable to predation by a variety of large carnivores (Kaczensky 1999). Wolf and dog depredation in central Italy accounted for a loss of 0.35% of the regional flock, most pronounced on the edge of inhabited areas. It peaked in spring and summer, due to sheep availability, and generally occurred at night. An average of three sheep died per attack, although there were also some mass slaughters (Ciucci and Boitani 1998). In some cases losses can be greater when livestock are in small pens when a predator attacks. Consequently the most common use for dogs across Europe does not appear to have been in working sheep, but in their use as livestock-guarding animals (Kaczensky 1999:62-4); this is a current widespread practice in extensive livestock rearing systems in the United States (Lorenz *et al* 1986:293) although wolves do not normally target cattle (Chavez and Gese 2006), and have been introduced to Namibia (Marker *et al* 2005). Extensive systems, whether utilising open or enclosed grazing therefore need to either make provision for livestock-guarding or accept a certain level of losses. Dogs are therefore likely to have formed an important component of extensive prehistoric husbandry systems.

2.3.3 Intensive farming

'*An housebande [farmer] cannot thrive well by his corn without he have cattell, or by his cattell without corn*' (Fitzherbert 1534).

Intensive agriculture can be defined as '*increased average inputs of labour or capital ...either on cultivated land alone, or on cultivated and grazing land for the purpose of increasing the value of output per hectare*' (Tiffen *et al* 1994:29; Netting 1974:39). This can include changes in land management and investment in structures. Applied to

animal husbandry, it is characterised by high stocking rates (although the number of animals need not be large) and/or housing animals, generally necessitating supplementary feeding, and requiring integration with, or access to, arable cropping. It is not a unitary process with simple causative factors, but multiple strategies applied in different ways by individuals and groups (Morrison 1996:587). 'Gardening' tends to describe small-scale but intensive cultivation, as opposed to a more extensive implication in the term 'agriculture'. The use of the term can in some ways diminish the importance of this form of very intensive production, and is rooted in our own terminology rather than reality (Leach 1997). Increased productivity of arable land can involve improvement of an existing technique (involution) and technological change (innovation) (Campbell 1997:226). Intensiveness has also been measured by the degree of fallow time allowed in a cropping regime (Boserup 1990), and often seen as driven by population pressure (e.g. Smith and Price 1994; Jones 1981). Diversity of practice is a normal element rather than a product of the arrest of a process of change (Morrison 1996:584). It does however normally involve various strategies for maximising output, such as grassland management and foddering. Intensive management necessitates greater permanency and physical control over animals, which has a number of effects, the results of which may be identifiable archaeologically and are discussed in the following chapter. In turn, permanent locations need to be placed effectively for the ease of provision of more labour.

'Intensiveness' is dependent on available labour. '*The capacity of modern agricultural methods to raise output almost exponentially while simultaneously reducing the agricultural workforce to a tiny proportion of the total, should not obscure the fact that in historical terms these are both recent and exceptional phenomena*' (Overton and Campbell 1991:1-2). Small enterprises in Gujarat produce more per hectare due to greater availability of labour from the immediate family (Newell *et al* 1997). In sub-Saharan Africa labour availability combined with cropping choice allows intensification (Stone *et al* 1990). Intensification in the Formative Period (1150-100BC) in the Basin of Mexico, involving investment in water management systems, had more to do with risk management of crop failure, rather than a response to population pressure (Nichols 1987). Choices over the utilisation of labour also affected productivity in 14th Century

Norfolk (Stone 2001:627-8). Intensification has costs and risks, and although it is generally economically driven, it has different manifestations (Adams and Mortimore 1997:152). The degree of labour involved is not necessarily directly related to the numbers of animals but to the total area of grassland in the system that needs to be maintained (Lewthwaite 1981:62). On Mennonite farms in Manitoba in the mid-20th Century, the intensiveness of arable production was only partly influenced by the land type, but organised into an infield/outfield arrangement, in which the most intensive treatment was afforded to the crops nearest the farmstead, regardless of crop type (de Garis de Lisle 1982). In the Nigerian Sahel, decisions over intensification are not made in isolation from other social and economic decisions, but employ labour flexibility; they are also responsive to external forces such as weather and social attitude (Adams and Mortimore 1997:158).

A high degree of integration of pastoral and arable farming is a feature of intensive systems. Maximisation of grazing quality and fodder production leads to greater need for manure, so intensive cultivation is complementary to intensive livestock management (Bogaard 2005:179). A considerable amount of fodder can be obtained from crop waste, and crops are also valuable as fodder and for green manuring (Limbrey 1978:25; Bryce and Wagenaar 1985). On the claylands of Medieval North Norfolk, up to a quarter of the legume crop was used as winter fodder, and some crops grazed green by livestock (Stone 2001:617). Strict regulation of livestock numbers is, however, required to achieve suitable levels of manuring whilst not depleting pasture, and needs flexibility to deal with seasonal fluctuations (Lewthwaite 1981:61). Failure to maintain a balance between arable output and the input of manure from livestock in the Peak District in the early 14th Century AD led to a collapse of soil fertility, a series of harvest failures and 'cattle plague' resulting in famine (Lake 1989:16). Intensive sheep rearing in Britain relied on folding of animals on a range of forage crops that were introduced in the 17th and 18th centuries, although it developed from the medieval practice of folding on stubbles for manuring purposes (Fraser 1947:106-112). Sedentary pastoralists in Greece kept flocks of goats as well as sheep, utilising browse on marginal areas around cultivation, and combining pastoral and arable agriculture. Sedentary herds tended to be small due to the labour intensiveness of producing and

gathering fodder (Halstead 1996:22). In the Methana peninsula, Greece, weeds pulled by hand from the arable crop would be fed to livestock held in yards, whilst light grazing of developing arable crops reduced their overall height and encouraged tillering, the production of additional growth points (Forbes 1998:25). Intensive Greek pastoralism combines three strands: keeping a large number of livestock per person; ensuring pasture use was optimum for productivity and nutrition; and emphasizing products with a high exchange value whilst small-scale mixed farmers tend to keep fewer animals for domestic consumption (Halstead 1996:24).

There tends to be confusion over terms (Table 14). 'Intensification' has been used interchangeably with 'expansion', and regarded as a linear process of development (van der Veen 2005:157). Intensification, is the change to intensive exploitation described above. '*It is useful to draw a distinction between intensification and expansion, the difference being analogous to the difference between concentration and amount*' (Morrison 1996:587). There has also been some confusion between concepts of output growth and productivity. Productivity can be defined by a variety of measures but simply it is the ratio of output to input, including labour. Increased productivity often relates to intensification of land use; extensions of the agricultural area may or may not affect productivity (Overton and Campbell 1991:7,17-18). Output growth can have a number of origins, of which rising productivity is only one. Changes in productivity might be discernable in the adoption of new cultivation technology or the development of livestock (Overton and Campbell 1991:29) and consideration of the theoretical outputs of plants and animals; there are however a range of problems of quantification of both product and land use (Jones 1991:81-2,86).

Table 14: Terminology (adapted from Morrison 1996:587, Bertaglia *et al* 2007:658)

Term	Definition
Intensification	Increase of yield per unit of land or unit of labour through investment via ploughing, weeding, manuring, construction of water supply and soil retention
Expansion	Increase in yield by utilisation of additional units of land and/or labour and animals
Specialization	Channelling of resources into restricted avenues requiring specialised and frequently intensive techniques
Diversification	Elaboration of productive strategies 'coexistence of multiple fallowing regimes, the use of spatially fragmented field locations, extensive arrays of cultigens and wild taxa, maintenance of a range of crop varieties, staggered planting times, and integration of agricultural and non-agricultural activities'
Marginality	Possible land uses are relatively limited due to higher altitude, shorter growing season, steeper slopes, less fertile soils or generally lower soil productivity.

Linear development from an extensive to an intensive strategy is not a given. These are merely two different approaches, two choices, and can occur in a spectrum. Specialisation can occur in intensive and extensive systems consisting of a focus on a particular aspect. Diversification is the employment of a number of methods or strategies, as has been advocated in modern British farming (Edwards 1980). Any or all of the approaches can co-exist within any particular system and also offer the possibility of differing behaviour by co-existing individuals or groups. In addition, assumptions should not be made as to the approach based on perceived marginality of land. Marginality is difficult to define due to its relativism and can be best understood with regard to its physical characteristics (Bertaglia *et al* 2007:658).

2.4 Dividing landscapes

'the attitude that a field is just a field is not altogether extinct, at least amongst archaeologists' (Fowler 1981:20).

Fields come in a variety of forms, sizes, construction and relationships to other fields and structures. 'Field system' likewise covers a variety of forms and arrangement of related land boundaries, whether they have come about through deliberate construction or have developed via cultivation or accretion. Field systems, boundaries and the layout of ancient landscapes have received a great deal of attention with regard to social organisation and control (e.g. Fleming 1985). The statement that '*fields are not just economic tools nor are fields always economic tools*' (Breen 2008:107) provides a summary of the thrust of recent study which seeks to distance the 'importance' of fields from their economic role. Fields are now able '*to illustrate the appropriation of particular places within social landscapes*' (Evans 2008:122). Boundaries inevitably have a range of meanings, and their construction would certainly, as Johnston suggests (2000:48), make a significant change to the landscape. There are also differences between *land use*, *land allotment* and *land division* (Chadwick 2008b), but there is often a relationship between the form of the latter and the other two. The analysis offered here in no way seeks to deny that boundaries and fields make statements about the occupation and perception of landscapes and are essential to the discussion of land ownership, tenure and territory. However, it does seek to place their function and utilisation centre stage; once those are understood,

they may have far more to contribute to our understanding of the construction of people's identities and structure of society. It is contested here that one 'meaning' that fields posses, is as an element of a technology. Whilst variability may result from length of development and local social preference (Chadwick 2008b:16), we should also regard them as varying in the way that other elements of technology vary, as a result of socially constructed technological choice (*cf* Pfaffenburger 1988; 1992).

2.4.1 Clearance and construction

Clearance is not needed for pastoral exploitation *per se*. Most livestock will graze woodland and over time may affect woodland growth. As Pryor comments, '*with pigs and other farm animals at their disposal, prehistoric farmers had no need to fell trees with axes*' (2006:41). Likewise, fields are not required for all forms of pastoral agriculture, but land within fields generally needs to be cleared in some way to facilitate its use, regardless of whether it is intended for cultivation or grazing. Clearance cairns have tended to be regarded as indicators of arable cultivation, but need not be; especially where it is accepted that they may relate to improvement of pasture, the difference between areas with cairns and those with more readily identifiable boundaries may be the duration of land utilisation (Barnatt 2008:49-50). Implicit in the act of bounding, is a desire to utilise the land more effectively for production, and it is rare to find fields of any type that have not been cleared. The reasons to create fields are limited, to keep animals in or out, to protect crops, improve the land, or define property, but arable cultivation has generally been assumed, distinct from the 'blank' areas of pasture and woodland (Fowler 1981:28,94-119), even for the highland zone (Fowler 1983:119-128). When animals are mentioned there is the further assumption that droves and boundaries existed to keep livestock off of crops (Mercer 1975:37), or that fields used for livestock and arable were located in different places (Fowler 1981:46). It has been assumed that real evidence for accurate interpretation is lacking (Reynolds 1987:39). In general terms, there is a lack of discussion of how fields functioned, and the interplay of arable and pastoral use. Fields play an integral part in rotation between arable cultivation and pastoral farming and grassland management. In many cases, it is likely that fields were dual purpose in prehistory, as much as they have been in British historical and ethnographic examples.

Even when in arable cultivation the crop may relate directly to the animal economy. Doyle (1870:17) comments that an acre of cultivated land yields as much fodder for a cow as three acres of pasture.

Boundaries will reflect to some extent the local geology (Fowler 1983:108), as where there is an easy availability of stone for drystone walling, it often needs to be cleared from the land. Some boundaries to fields were most likely provided by natural features such as streams, woodland and cliffs (Fowler 1983:101). The simplest barrier is a hedge. Managed hedges are capable of keeping stock in and wild animals out, and provide shelter. Both animals and arable crops benefit from this (Maclean 2000:19-20,26). '*To the farmer, the hedges he has inherited...are primarily pieces of fixed agricultural equipment*' (Harvey 1980:57-58). However, hedges must be actively managed to maintain their stock-proof nature and hedge species that are left to grow too large will develop large numbers of surface roots that impoverish the soil in neighbouring fields (Henderson 1944:38). Many laws in Early Medieval Ireland are pre-occupied with the regulation of trespass by livestock and the need to adequately maintain fences. The *Bretha Comaithchesa* classifies what it regards as a proper boundary, including stone walls, specified to be four feet in height, banks and ditches, and two types of fence, often using blackthorn as a barbed-wire equivalent (Kelly 2000:135,372-375). The likelihood is that the full range of boundary types was used in prehistoric Britain, with similar preoccupations on access and maintenance. Field systems are also not only about fields themselves but other elements that enable them to function such as arrangement in relation to water sources, access, open land, tracks, and settlement. The recognition and interpretation of these elements is explored further in the following chapter, but their importance in the past is also addressed in the Irish law texts where land with tracks leading through it and specifically to cow-ponds, was more valuable (Kelly 2000:391).

2.4.2 Fields, ownership, tenure and society

'*the basic factors of production on any farm are land, labour and capital*' (Slater 1991:73).

Concepts of ownership of land, animals and products can be complex. The medieval English common field system was a combination of communal and private ownership. Land under arable cultivation was the holding of the cultivator until after harvest when it reverted to communal grazing. The maintenance of division in field layouts was dependent on particular inheritance systems (Campbell and Godoy 1992:99,102). The attitude to the utilisation and regulation of wild resources in the Medieval period in Northern Europe is also enlightening. Where there was competition for pannage resources, it was the numbers of pigs that were regulated, but no effort was made to manage the woodland itself, as the mast was regarded as provided by God and not in need of regulation (Vera 2000:129). Likewise, the allotment of land need not actually require a physical barrier, being implicit rather than explicit, or understood via landmarks and natural features. Also, a range of different land uses, of which agriculture is only one, may give rise to issues of land allotment, tenure and land division (Chadwick 2008b:4-5). The interplay of natural and anthropogenic landscape features (Bender *et al* 1997; Herring 2008) communicate a number of meanings and experiences.

Overgrazing by pastoralists on commonly held pastures has often been regarded from the perspective of the 'common property problem', whereby the combination of the individual ownership of the animals outweighs the communal ownership of the grazing resource, leading to short termism by individuals maximising their own use of the resource. However this model makes the assumption that people will compete rather than co-operate (Livingstone 1991:80). Mongolian herders, although based on the unit of the individual household, co-operate between households to enable the flexibility of the greater labour resource to be brought to bear at points in the herding cycle that demand the greatest labour input (Barzagur 2003:23). Co-operative behaviour of a variety of types occurs widely amongst smallholders in developing countries (Gerichhausen *et al* 2009). In Botswana, what appears to be selfish maximisation has

been shown to actually be a strategy in good years to offset drought years, whilst the fluctuating stock numbers allow a recovery period for soils and vegetation (Livingstone 1991:81,85). The conclusion is that overstocking in a commons situation does not necessarily automatically lead to conflicts over land use that need to be regulated but may be an adaptive strategy in and of themselves. We should also take account of strategies to deal with ownership of the animals. The horse herds of Mongolia, because they are constantly on the move, and may become indistinguishable from someone else's animals are branded, allotted to each owner and inherited by a complex series of rules accompanied by complex ceremonial. Both society and the herd were patrifocal and the inheritance and evolution of the brand signs (Humphrey Waddington 1974) seems to reflect a genealogical tree.

Land division can help to avoid conflict between competing interests in farming communities (Pryor 2006:37,69). Whilst competition for resources may not necessarily provide the impetus for field construction, it requires a new understanding of land as a controlled resource as well as a lived space. Giles (2007:109) has acknowledged both the role of moving through the landscape with animals, and knowledge of the animals themselves of landscape, in generating the sense of belonging in a particular place, with relation to Early Iron Age land division in East Yorkshire. Neither do fields exist in a cultural vacuum. Later field systems frequently reference or incorporate into their layout earlier landscape features and monuments, including examples in south east Dorset (Fowler 1981:51), either confirming earlier understood divisions in the landscape or appropriating symbols of the past.

Incorporation of houses into field walls includes them in the material structure that defines available resources. It symbolically links the domain of the family (invoking concepts of kinship and inheritance) to the fields (related to fertility, production and subsistence). The rhythms of daily life in both house and field are therefore joined and contribute to the structuring and negotiation of land tenure (Johnston 2001:100). Peterson (1990:590) observes that the arrangement of boundaries conveys information. If the arrangement is purposeful then the most likely explanation is that it supports land management. However, it cannot be assumed that a uniform pattern of land division indicates control by a single individual or group, and there are issues with

regard to the concept of 'planning'. Regularity in a system need not equate with a single event or planned approach. Planned and unplanned expansion could take place in a short or long period (Hayes 1981:105). No one shape of a field system can be seen as more planned than another. Regularity is therefore likely to have other origins, and it may or may not have been 'planned' at a centralised level. One explanation may be entirely utilitarian; it takes less distance of boundary and therefore work to create adjoining related fields than separate compounds (Fleming 1985:135-9).

Whilst discussions of tenure of land and territoriality are important for our understanding of society, and examination of these landscapes with those issues in mind and from a theoretical perspective are entirely legitimate, there are dangers. When Wickstead (2008b:7) says of her work,

> '*I 'translocate' tenure by moving the theory of tenure away from traditional accounts which link it to land division and agricultural production. By considering tenure as part of the constitution of identities I move it away from the narrowly conceived category of productive labour and the 'subsistence economy*'',

she is embarking on a useful approach to understanding the construction of Bronze Age social identities, but actually recreates the hierarchy of importance in which 'subsistence' and all things associated with it are largely disregarded by theorists. This creates problems in interpretation twice over; not only would 'subsistence' constitute the framework of meaning and activity for the vast majority of people in the Bronze Age, inseparable from their more 'abstract' views of the world, and entirely embedded in their 'social' choices, but by effectively denying the importance of the fundamentals of the embodied practicalities of existence, we fail to address them and consequently miss opportunities to add layers of nuanced understanding to our social interpretations. When Wickstead states,

> '*It is now widely recognised commonsense notions of economic efficiency and function do not explain enough*' (2008b:30),

she is entirely right; however, abandoning all attempts to understand the mechanisms by which systems operated we lose the opportunity to eliminate 'function' and fully

identify other influences. For a start, the concept of 'economic efficiency' is entirely socially constructed; a wide variety of strategies can be 'efficient' within their own framework of social choice. Pryor (1996:317) observes that sorting, exchanging and culling animals would be unlikely to be simply regarded as a purely economic process. Wickstead's (2008b:152) conclusion was that '*landscapes of land division do not signal 'fragmentation' into individual territories but instead, provide evidence for expanding interconnections between groups'*. She emphasises the way that entities permeate one another rather than making distinctions between 'households' and 'communities' (Wickstead 2008b:153); we can build on this, if we accept that the social identity of livestock is equally permeable, and they can be regarded equally as actors within the landscape whose needs and preferences are responded to, and who gain biography.

2.5 Using Herds

Animals provide a number of products, both economic and conceptual that can be exploited, and in addition to the choices of the organisation of their management outlined above, there are also choices to be made about how to achieve the 'aims' of keeping them. Animals can take on a variety of meanings that may or may not be related to their practical role; the degree to which we can ascertain those meanings is explored further below. The physical products that they provide are shown in Table 15, along with British historical comments on use. This not only indicates the possibilities of the resource, but the use to which they have been put in the British Isles since the medieval period.

Table15: Animal products

Products	Historical use
Sheep	
• Meat • Milk • Wool • Hides • Horn • Bone and soft tissue • Manure	In Early Medieval Ireland the sheep was a basic unit of currency (Kelly 2000:75). Fleece quality was one factor to be considered when buying a sheep (Kelly 2000:71). Sheep were milked, but the milk held to be inferior to that of goats (Kelly 2000:73); milking sheep was a consideration in the weaning age of lambs in 16th and 17th Century English texts (Davis 2002:54). Modern systems cull when fertility reduces and teeth make feeding difficult; an additional number of animals will die or develop udder disease (Goodwin 1979:84; Hart 1985:36). English texts of the 16th-18th Century indicate that slaughter times tended to vary depending on prevailing preferences with regard to the meat (Davis 2002:54).
Goats	
• Meat • Milk • Wool	Goats were not a particularly important animal in Early Medieval Ireland, and were valued at less than a sheep, but largely used for their milk (Kelly 2000:78-9), and the quality and quantity of their milk, the output being up to three times that of sheep

• Hides • Horn • Bone and soft tissue • Manure	was noted in the 16th Century. They were generally only kept in small numbers, although widely, although it was noted in the mid 17th Century that because of their use in grazing 'wild and barren places' there were notably more of them in Devon and Cornwall (Davis 2002:57). Late 17th Century recommendations were to cull the females at eight years (Davis 2002:57). In early medieval Irish sources there is an association of women and sheep, presumably due to a division of labour in textile processing (Kelly 2000:67). The care of lambs was regarded as being one for children (Kelly 2000:69).
Cattle	
• Meat • Milk • Hides • Horn • Bone and soft tissue • Manure • Traction • Warmth?	Culling of cattle in the 18th Century expected cow calves to make a beef weight at three years but steers in four or five (Lisle 1757:259). Cows produce colostrum for the first four days after calving, and calves can be removed after this time. If calves are fed by their mothers, they can be allowed the first of the milk, and the rest of each milking taken. Cows need to be milked twice a day (Manolson *et al* 1988:177). The greatest flow of milk occurs in the three months after calving coinciding with the greatest grass growth (Doyle 1870:31), whilst in the early 14th Century a five-six month lactation is indicated at up to 130 gallons per cow per lactation (Stout 1993:19); 7th-8th Century Irish texts appear to have needed the calf present in order to milk, in 13th Century England William de Henly suggests calves could be weaned at two months, and this appears to have been a trait that disappeared earlier elsewhere (McCormick 1992:202-3). A year-long lactation occurred in early Irish cows not put to the bull (Kelly 2000:41). Prior to mid 18th Century improvement, cattle were of the longhorn type, a triple purpose animal for milk, meat and draught (Manolson *et al* 1988). There were broadly different cattle populations across southern Britain, classified by coat colour (Stout 1993:10). The slaughter of calves in early Christian Ireland appears to have not included very young calves but keeping them to a full meat weight. Some sources give references to slaughter for ritual purposes (Kelly 2000:52). Early medieval Irish cattle appear to have provided the majority of milk, although sheep and goats were also milked (Kelly 2000:52). Bleeding of cattle was practised in Ireland in the 16th-18th centuries, and is referred to in early medieval texts (Kelly 2000:54). Cattle body temperature is around 38.5°C, and a strong circadian rhythm that gives the highest temperature in the late afternoon and evening; the fluctuation is less in the winter (Kendall and Webster 2009:158).
Pig	
• Meat • Skin • Bone and soft tissue • Manure • Waste disposal	'*the husbandman's best scavenger and the huswife's best sink*' (Markham 1614 quoted by Lake 1989:37). Pigs are a quick maturing animal, even in unimproved types. Like other livestock the fastest weight gain occurs in the first few months. Piglets can quadruple in weight in the first three weeks of life although the feed to weight ratio tails off as the animal matures. (Goodwin 1973: 37-9). There are two well known pig management systems, herding or sty rearing. Herding has been regarded as the likely prehistoric management system (Reynolds 1987:27). Modern British pig production is intensive and relies on housing and supplementary feeding. Modern pigs are however considerably different from those farmed in the past, being much 'improved' (Goodwin 1973). In free range pigs in Sardinia and Corsica, the best slaughter time is regarded as being in winter before a fodder shortage, and the age of the animal is of lesser importance (Albarella *et al* 2007:300). Slaughter of pigs in Irish medieval texts occurred as sucklings, at full meat weight, or for sows after 2-3 farrowings (Kelly 2000:84-5). Decisions on slaughter age depending on the purpose of the meat, either as pork or bacon, were made from at least the early 18th Century (Davis 2002:56).
Horse	
• Meat • Milk • Hides • Bone and	Two and three–year olds are still growing but can be worked. As horses are a slower maturing animal, they require greater investment in raising them (Bryce and Wagenaar 1985:96). Horses were noted as being less efficient as traction animals than oxen in the 16th Century, with the added disadvantage that old animals tended

soft tissue • Manure • Traction	to lose muscle, whereas old oxen still retained meat (Davis 2002:50). Horses only became the predominant draught animal in Britain in the 17th Century with the invention of a range of lighter cultivation equipment (Lake 1989:29). Animals in the 18th Century were generally worked on a light basis from two years of age, and increasing the amount of work gradually until seven years (Davis 2002:55). 16th and 17th Century sources recommend the castration of males within the first two weeks of life (Davis 2002:55). The average 19th Century farm horse would be worked from four or five years old until they were about 14, continuing with light work until about 20 (Lake 1989:30). Various methods of catching wild or feral horses have been recorded ethographically. In North America, native peoples used corralling in oval enclosures, whilst individual animals could also be chased down. The process by which they were then tamed was simple but difficult, with some individuals more expert than others (Levine 1999:39-40).The way that horses react to people (and thence the ease with which they can be utilised and the relationship that can be built especially between horse and rider) is a combination of experience and underlying temperament. These interactions are not always linear or predictable. Yearlings that had been intensively handled, and those that had been completely neglected in one study were less easy in their contact with people than those that had been regularly but intermittently handled (Hausberger *et al* 2008). Calmer animals are produced by handling from weaning onward, but not before; pathological habits such as wood chewing and cribbing appear to be manifestations of stress at weaning, but have not been observed in feral horses (Hausberger *et al* 2008:12), so there may be advantages to non-intervention and extensive rearing. Neither does there appear to be any advantage in later behaviour in handling of foals by people at birth or indeed up to the time of weaning (Hausberger *et al* 2008:15). However, foals that have see their dam being handled positively at 6 months old were more responsive to human contact (Henry *et al* 2007), which might argue for the efficacy of a degree of human interaction, even if herds were semi-feral. Handling of yearlings has been shown to increase their tolerance to unfamiliar people and the degree to which they are explorative and engaged with their handlers (Minero *et al* 2009). Abnormal behaviours such as crib biting across a number of countries, appears to be related with extensive forms of rearing and a lack of handling of animals (Parker *et al* 2008).

2.5.1 Managing for meat and milk

Most pastoralist societies employ a strategy to maximise the growth of the herd, retaining females as long as they are productive and removing young males to conserve fodder availability. The choice is often not whether to cull, but at what age, depending on the primary utilisation of the herd for meat or milk (Reid 1996:49-50). Resources may also be subject to other influences. From the perspective of 'relations of production' the utilisation of animals, although they are part of a husbandry strategy, may also be part of the negotiation of power relations. In Southern Uganda, the age (size) that an animal appears to have been allowed to attain in early 2nd Millennium AD sites appears to relate to the size of the settlement, and therefore the ability of that settlement to consume the animal. As some sites became very large, the supply of meat may have become a method of negotiation of relationships (Reid

1996:51,53). Understanding how these mechanisms work in southern Africa requires understanding whether elite sites themselves had herds or were bringing them in. The lack of evidence for stock keeping facilities at Great Zimbabwe and the contrast with nearby site assemblages (with more older cattle) seems to indicate a consuming location (Reid 1996:53).

2.5.2 Manuring

'*preservation of fertility is the first duty of all that live by the land....in the soil lies all that remains of the work of countless generations of the dead*' (Henderson 1944:35)

Manuring has been described as the central hub of the modern organic farm (Blake 1990:52). Intensive arable cropping exhausts soil nutrients, and manuring is a basic prerequisite of agricultural intensification (Bakels 1997:442,444; Guttmann 2005:228). Manured soils can give twice the yield of cereals (Barker 1985:51), and it can assist in maintaining and reinvigorating grassland (Frame 1992:143). The key elements required by plants are nitrogen, potassium, phosphorus and micronutrients (Guttmann 2005:226-7), and manure also assists water retention and cohesion on light soils (Guttmann *et al* 2005:68-9). Manure layered in a covered yard is more valuable than that left in the open, where exposure to the elements washes out many of the nutrients. Nitrates leach from fields in wet weather (Shiel 1991:59). It is better applied directly to the field (Henderson 1944:100). It can create disease problems if applied in too great a quantity at the wrong time and reduce magnesium uptake leading to 'grass staggers' (ADAS 2001:14). Different value has been placed on particular animal manures. Sheep and pig manure are regarded as the most valuable, then horse, whilst cattle manure is less valuable due to high water content. The exact type of material used may reflect the economic base of a site by demonstrating what resources were available (Guttmann 2005: 225; Guttmann *et al* 2005:68). A wide variety of materials can be utilised in manuring, as shown in Table 16, although animals waste normally contributes the greatest proportion, both in frequency and volume.

Table 16: Manuring materials

Material	Efficacy	Use
Animal manure	Phosphate, potassium and nitrogen. Provides volume. A modern 450kg dairy cow can produce 42 kg of manure per day, and a 90-130kg pig, 7.1kg (ADAS 2001:21). Burnt material, used as bedding, absorbs liquid and increases nutrient content (Fenton 1981:211).	Widespread (Bakels 1997:444; Guttmann 2005:70). It was believed in the 19th Century that the quality of farmyard manure relies on the quality of the animal's diet (Doyle 1870:13). Manuring was regarded as a prerequisite for arable crops in early medieval Ireland; cattle dung was regarded as the best (Kelly 2000:57,229).
Human faeces	Phosphate, potassium and nitrogen.	(Bakels 1997:444; Guttmann 2005:70)
Silts from ditches and wetlands	Variable	(Bakels 1997:444; Guttmann 2005:70)
Chalk or lime	Counters low soil pH	Marling of fields was understood by the Gauls according to Pliny (Appelbaum 1954:106).
Calcareous sands	Counters low soil pH	Dispensations of Richard I and Henry III and a 1609 Act of Parliament allowing the removal of sea sand in Cornwall for this purpose (Staines 1979).
Turf and peat	Variable	(Bakels 1997:444; Guttmann 2005:70)
Bracken	Phosphate, potassium and nitrogen.	(Bakels 1997:444; Guttmann 2005:70)
Hearth ash	Calcium and potassium, and counters low soil pH.	(Bakels 1997:444; Guttmann 2005: 226-7; Fenton 1981:213)
Seaweed	Phosphate, potassium and nitrogen. Increased water retention.	(Bakels 1997:444; Guttmann 2005:70-73; Fenton 1981:213; Haslam and Hopkins 1996)
Bone and food residues	Phosphate, potassium and nitrogen.	(Guttmann 2005:227-228).
Crops	Legumes - nitrogen, assist soil structure	Medieval Rimpton, Somerset legumes were deliberately cultivated as 'compost' (Stone 2001:624).

It has been assumed that prehistoric agriculture was constrained by lack of manuring and over winter foddering (Forbes 1998:29). This was based on understandings of medieval European farming (Postan 1973). However, recent reassessments challenge these, and lack of integration may have been a greater issue (Overton and Campbell 191:35). Prior to the Black Death, English farming was neither static nor lacking in variability, and some sources previously relied upon referred to management systems caused by landlords more interested in cash income than maximising output (Stone 2001:612). In pre-industrial farming there were a limited range of inputs that could be utilised, and the exact effects of particular additives may have been difficult to discern (Shiel 1991:52). However, Roman authors display a detailed understanding of the complexities of manuring (Fenton 1981:210).

During the medieval period in Norfolk, tenants were instructed to graze their sheep on the lord's land due to the importance of the dung (Campbell 1981a:17; Lake 1989:31). Utilisation of manure has been demonstrated for medieval North Norfolk with increased arable output when the livestock numbers were high, especially cattle; fields were sown with arable crops the year after sheep were pastured on them (Stone 2001:625-6). Intensification of farming in this area involved removal of stock from the fields, but the maintenance of fertility, which was achieved by cultivation of legumes and bringing in manure from pens, collecting it from common grazing, and supplementing it with nightsoil (Campbell 1981a:22). The value of manure was appreciated in 16th-18th Century English farming texts. Several sources refer to the particular efficacy of sheep dung and the practice of folding, in some cases leading to renting of sheep for the purpose (Davis 2002:58). Folding sheep was carried out in Somerset in the 19th Century (Fussell 1948:65,67), and up until the 1930s, sheep were moved on a daily basis between grazing and arable land for night folding (Lake 1989:31). Sheep folding as part of an integrated arable strategy in lowland England only declined in response to poor prices and the introduction of mechanised farming and chemical inputs after the First World War (Hart 1956:265). This demonstrates a continuity of understanding and utilisation that makes it hard to assume that manuring was not part of prehistoric British agricultural systems; as such its detection could provide an insight into integration and intensity of production.

In the Northern Isles from the Neolithic until the Iron Age, arable plots were placed on top of midden heaps, and cultivated *in situ* (Guttmann 2005:231-233). Large Late Bronze Age/Early Iron Age middens in southern England, potentially have a diversity of explanations but may have been used in this way. At Runnymede the mixing of top layers was not regarded as due to cultivation, but a cultivated midden has been identified at Hazelton, Gloucestershire (Guttmann 2005:233; Macphail *et al* 1990). Middens result from management of debris, production and processing of raw materials and may have a symbolic role indicative of fertility. However, although the accumulation of refuse does not automatically indicate manuring, the scale does indicate the centralised location of livestock (Needham and Spence 1997:84,88). Manuring may imply the over-winter housing of stock in order to generate a muck

heap to be spread (Applebaum 1954:105). With this example of the interplay of husbandry and by-product, the next chapter turns our attention to the ways in which these types and combinations of practices may be identifiable archaeologically, and offers ways in which they can assist us in understanding the organisation of ancient pastoral farming.