NEW VIEWS ON GRAZING AMONG SITE MANAGERS

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Grazing animals are the latest fad to hit nature areas. For a long time, grazers were believed to be nature's greatest enemy and consequently much knowledge about grazing faded from our collective memory. Now grazing is carried out on many different theoretical grounds. Experiences up to now have provided valuable knowledge.

Many centuries ago, wild herds of large herbivores roamed the lowlands of western Europe. As man slowly acquired dominance of this large region, domesticated grazing animals which were kept for consumption took the place of wild herds. Extended periods of intensive grazing on the dry sandy soils resulted in a landscape of heaths and inland sand dunes. In the late 1800s, the tide finally turned. Keeping herds of grazing animals was no longer as profitable, economically, as it had once been. And people were also becoming aware of the importance of preserving nature. Initially, nature conservationists concentrated only on buying up land, but they soon realised that all these sites needed to be managed. Grazing was not the first thing that site managers thought of. The devastating effect of intensive grazing on half-open landscapes in the past was too fresh in nature conservationists' minds. Only recently has grazing come to be regarded as a valuable management tool for various types of sites. Unfortunately, wild grazing animals have been gone so long from our landscape that we have little cultural-historical knowledge left to draw on.

Grazing as a management tool

Site managers especially tend to use large herbivores on sites which were traditionally grazed by livestock, and which still bear evidence of this, such as heaths, chalk grasslands, dune grasslands, stream basin grasslands, dikes, salty grasslands and boggy grasslands along rivers and on peat soils. Now, however, grazing is also applied in relatively new washlands and in other nature development projects. Here, grazing may be applied for two purposes. The first is to preserve, restore or develop a special type of landscape characterised by a certain mix of herbage, scrub or woodland. The second is to preserve or facilitate a certain type of vegetation, species or target species. Site managers decide where animals may graze, when and for how long. Site managers also decide the number and species of animal to be put out to graze.

Heaths

The purpose of heathland grazing is to maintain or improve the characteristic dwarf shrub vegetation and its accompanying flora and fauna. Grazing counters encroachment by trees and shrubs, grasses and other weeds or herbage, and ensures the rejuvenation of heather.

Until 1985, grazing was usually carried out by sheep. This practice followed the latest historical data, which also prescribed a stocking density of one sheep per hectare. However, this soon proved inadequate to stop encroachment and the succession of heath to woodland. This process was accelerated by nitrogen deposition and mineralisation of the organic components in the soil due to falling groundwater levels. The impact was most dramatic on boggy heaths, where grazing by sheep could not check the rapid encroachment of purple moorgrass. Many site managers responded by raising grazing intensity to two or more sheep per hectare. Even then, grass encroachment continued to be a problem. The higher stocking density also led to overgrazing of heather (both older shrubs and young seedlings), so that the net effect seemed to be further deterioration rather than improvement. The high grazing intensity also had a negative effect on populations of snakes, lizards, insects and ground-nesting birds.

There were records of large-scale grazing by cattle on Dutch heaths before the 18th century and this, together with promising reports of grazing by cattle and ponies on heathland abroad (most notably the New Forest), contributed to the growing use of cattle and ponies for grazing. Grazing by cattle has had positive results: grass encroachment has slowed down, while common heather, bell heather and other rare heathland species have flourished. But the effects of grazing are still heavily dependent on the number of grazing animals and the duration of grazing in relation to food availability. For year-round grazing on heaths, the availability in winter of adequately digestible food (>40%) with sufficient proteins (>3%) is crucial. On many wet or boggy heaths, the quality of forage in winter is atrocious, primarily because of the low protein content of purple moorgrass. In these areas, year-round grazing often has a negative impact on both the vegetation and the animals.

On drier heaths, we now realise that prolonged grazing by 1 sheep per hectare or more than 1 bovine or pony per 3 hectares is detrimental to reptile populations. Feasible grazing intensities are 1 cow or pony per 5 or 6 hectares year-round.

Because high grazing intensities also have negative effects, and because it cannot halt the succession process on its own, many site managers have adopted supplementary measures, like turf cutting, to combat grass encroachment and the build-up of dense litter layers. Such measures remain necessary in order to preserve the high nature value of our heaths for future generations.

Dunes

Animals were commonly put out to graze in the dunes along the coast until

well into the 19th century. It has been many decades since large herbivores have trod the coastal dunes and during this time, many places have become overgrown by reeds, scrub and woodland, while dune grasslands and vegetation dependent on exposed strips of sand (mosses) have declined. Site managers have recently re-introduced grazing in their efforts to restore previously common low vegetations and the fauna that comes with it.

In the last twenty years, grazing animals have been introduced in more and more dune reserves. Some sites are grazed year-round, others only in the growing season. Ponies and cattle are most commonly used. Grazing intensity typically varies from one cow or pony per three or four hectares to one cow or pony per 20 hectares. Grazing intensity is primarily determined by the type of land. In boggy dune valleys and areas of thick scrub, grazing is usually seasonal. In winter, food is also scarce in drier areas. The low nutritive value of species such as bushgrass and European beachgrass, in particular limits the possibilities of year-round grazing to very extensive grazing by ponies.

Although we do not have long experience of modern grazing practice in the dunes, we are already seeing many positive effects. Encroachment of trees and shrubs has been brought to a halt, and grazed wasteland is becoming more open. Vegetation is becoming more diverse and this has a knock-on effect on species diversity in general. Dune valley vegetations, dune heath, dune grassland, transitional grassland between heath and waste, as well as dune scrub are developing well.

Salt marshes

Salt marshes, mudflats, and other coastal plains have been grazed for many centuries. In most of these areas in the Netherlands, this tradition continues today. The primary reason for grazing from a nature manager's perspective is that it controls the influx of herbage on the drier parts. The vegetation that is typical for this landscape, ranging from halophilous plants to

Sheep grazing on moor land: introduced to reduce grass invasion, only partially successful because of resulting nitrogen deposit.

plants which help reduce the salinity of the soil, is thus preserved. This management benefits waders and terns, which use these sites as their breeding grounds, as well as other bird species which forage on the mudflats, such as geese.

On most sites, grazing is carried out by cattle and sheep. Horses are rarely put out to graze here because they are more susceptible to hoof infections and risk becoming stuck in the many creek beds running through the flats. Very little food is generally available in winter, so grazing is usually restricted to the summer season. Grazing intensity is usually fairly high, over 1.5 cow per hectare or 10 sheep per hectare. In this way, the growth of plants like sea couch and sea wormwood is checked in favour of species which are more tolerant to being trodden on, like mud rush and thrift. A general effect of grazing is an increased variation in the vegetation structure, which benefits species diversity on a smaller scale. Intensive grazing does, however, cause more nests to be trodden on and adds to stream bank erosion.

Dry grasslands

There is a long tradition of grazing on dry grasslands, such as river dunes, stream embankments, dikes, chalklands and transitional grasslands between heath and waste. In the recent past, however, grazing on chalkland has been less common, primarily because the areas of protected chalkland tend to be too small for grazing. There, the preferred management method is mowing, with some grazing in autumn or early spring. In larger reserves (> 5 ha), both seasonal grazing and year-round grazing occur. The purpose of grazing is to preserve, restore or develop grassland ecosystems, which are low in nutrients and rich in species and structure, or herbage and margin ecosystems. Scrub ecosystems often develop, too. Management of these areas also aims to preserve insects (butterflies, grasshoppers, membrane-winged insects), small mammals and song birds (which often feed on seeds and insects).

Dry grasslands are grazed by cattle and horses, and often by sheep, too. The grazing of river dune grasslands (which also feature juniper berry copses) and stream embankments is often combined with grazing of boggier areas in the floodplainns. Grazing of transitional grassland on dry sandy soil is often combined with heathland grazing. Cattle and ponies are used in year-round grazing.

Cows can be used effectively on many types of terrain to maintain varied vegetation patterns.

In general, dry grassland grazing has good results. Encroachment and succession are sufficiently checked and characteristic target species are developing well. A secondary effect of grazing is a bumpier terrain, which stimulates greater diversity in mosses and higher plant species. The greatest effects have been achieved on chalk grasslands, river dunes and stream embankments. Nitrogen deposition on dry, acidic and oligotrophic sandy soils sometimes makes for less positive results. Extended grazing at higher intensities also has a negative effect on herbage and margin vegetation, and on dependent insect populations. Grazing in very small reserves also slows down herbage and margin vegetation growth. In particular, smaller sites may be negatively affected by year-round grazing.

Grazing and succession

Modern experiences with grazing on different types of terrain have taught us that grazing can only check the growth of vegetation over a longer period of time if grazing intensity is kept consistently high. At the same time, however, this practice is detrimental to many other organisms. A consistently high grazing intensity may result in open heathland, but not in heathland with a high nature value. Higher nature values normally depends on other processes, which create pioneer ecosystems (can also be achieved by turf cutting), in combination with a lower grazing intensity. It is becoming more and more evident that nature may benefit particularly from fluctuations in grazing intensity. Intensive grazing for a limited period of time might be necessary to counter succession on heaths. Once the heath has rejuvenated, intensity may be reduced to avoid negative effects on other flora and fauna. If no intensive grazing were to take place at all, fauna would likewise disappear in time. The negative effects of intensive grazing might be limited by restoring heaths one bit at a time.

Grazing on a larger scale

Year-round grazing raises the question of winter food supply. Most summer grazing areas tend to comprise only one type of terrain, and this will not do for year-round grazing. In particular, grassland on peatland soils, boggy heath, salt marshes and boggy stream basin grasslands tend not to have sections which do provide sufficient quantities and quality of food in winter. In these areas, it is necessary to provide supplementary feed or bring the animals inside in winter. The latter is a costly affair, both in terms of money and manpower (fodder must be collected, animals must be fed, manure cleaned up). There are however few possibilities for moving animals to winter grazing sites. Either the sites are too far away or they are too small. Potential sites are usually dry and have sufficient green herbage in winter (for example, heath and woodland with plenty of wavy hair grass). We therefore recommend establishing reserves with sufficient variation in terrain types for year-round grazing. It might also be possible to relocate grazing animals to winter sites, a type of transhumance, but the low plant growth rate in winter should be

Larger nature areas will be needed in the future to achieve more natural forms of grazing.

Area sizes and numbers in the Netherlands

An estimated 400 nature areas in the Netherlands totalling about 45,000 ha are grazed by cattle, horses and/or sheep. About 75 areas are bigger than 100 ha with a total of 35,000 ha. In the future this number will probably increase considerably due to the expansion of grazing on existing open natural areas and the introduction of grazing herbivores in new landscapes.

Woodlands are not usually grazed by domestic animals, but by wild roe deer (nearly everywhere in the country), red deer (Veluwe only), fallow deer (small areas of the Veluwe and dunes) and wild boar (Veluwe and Meinweg). It is difficult to get an accurate picture of the total numbers of these large herbivores and their owners. The total number of cattle in natural areas was estimated a few years ago at about 10,000, the vast majority of which were brought in by third parties for summer grazing (agistment). Horses numbered a few thousand and sheep approximately 9,000. Both horses and sheep are more or less equally divided between seasonal and year-round grazing.

Ownership is also equally distributed among nature management organisations and private individuals. It is remarkable that nature managers usually tend to agist especially on the richer soils, which are most interesting for farmers. On poorer soils, nature managers more often have to acquire their own animals.

Various breeds are used. Cattle breeds grazed year-round are mostly Scottish Highland, Heck and Galloway. In addition to Meuse/Rhine/IJssel and Friesian-Holstein, the beef-producing breeds (Charolais, Limousin, Blonde d'Aquitaine, Piemontese, Saler, Simentaler, Whiteheaded and Dutch Belted) are placed in agistment in nature areas primarily in spring and summer. Horses and ponies are mostly Konik, Icelandic pony, Shetland pony and Norwegian fjord horse. Sheep used are mainly Veluwe heath, Drenthe heath, Kempen heath and Schoonebeeker.

Area (main manager, province)	area in ha	type	animals	number of animals
Oostvaardersplassen (Staatsbosbeheer; Flevoland	5,600	wetland, clayey marshes and meadows	heck cattle konik horses red deer	600 600 800
Veluwezoom (Natuurmonumenten; Gelderland)	4,800	dry sandy area with woods and heathlands	Scottish highland red deer (free ranging population in a larger area)	250 p.m.
Lauwersmeer (Staatsbosbeheer; Groningen, Friesland)	3,100	wetland, clayey marshes and meadows	Scottish highland konik horses	225 75
Planken Wambuis (Natuurmonumenten; Gelderland)	1,700	dry sandy area with woods and heatlands	New Forest ponies	65
Kampina (Natuurmonumenten; Noord-Brabant)	1,200	dry and wet sandy area with woods and heathlands	cattle horses	50 70
Slikken van Flakkee (Staatsbosbeheer; Zuid-Holland)	700	wetland, clayey meadows	Heck cattle fjord horses	150 75
Kennermerland Zuid (Natuurmonumenten; Noord-Holland)	735	dunes	Shetland ponies	42

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considered when selecting a winter grazing site. In general, one hectare of nutritious summer grazing area is equal to about ten hectares of poor winter grazing area.

Grazing, a natural process

In natural or near-natural landscapes, landscape patterns and populations of flora and fauna are largely the result of spontaneous natural processes. Measures are often needed to facilitate the most important key natural processes. One of these measures is grazing. In theory, the make-up of grazing populations with respect to number, gender and age is no longer interfered with after their introduction to an area, and the animals are free to graze where they want for as long as they want. In these landscapes, grazers are an integral part of the ecosystem, no different from trees, fungi, predators and abiotic factors such as climate, geology and soil processes. Here, grazing is not a means to preserve or develop certain landscape patterns or vegetation types. Instead, introduced domesticated cattle and horses play the part of "wild" descendants of the extinct species, aurochs and tarpan. Their role is comparable to that of wild herbivores such as roedeer and red deer. The introduced grazing animals are in effect subjected to a process of de-domestication.
At the moment, this type of grazing has not been practiced long and only in a

handful of nature reserves. Because of the absence of suitable European references, there is a great range of ideas about the role of grazing. One of the biggest problems is that nearly all areas are too small for large herbivores' seasonal migration between different landscapes and natural predation. Naturally, grazing animals die a natural death in the outdoors. But the lack of predators means that fast-growing populations may also undergo periods of widespread suffering and high mortality. Society however does not wish to accept this consequence, so that nature managers must periodically intervene in order to check population growth. However, it should be kept in mind that in the last truly pristine wilderness areas on this planet, fluctuations in populations are a normal occurrence which tends to have a positive effect on biodiversity. During periods of high grazing intensity, vegetation becomes more open and this benefits species which have a low competitive ability. Species which are sensitive to grazing also benefit from the subsequent period of low grazing intensity. It makes more sense to control populations by periodic culling rather than maintaining a fixed number of animals throughout the year, the method to control populations of game animals. Population control is as yet a largely unknown aspect of grazing, which urgently needs to be studied.

The numerous grazing projects carried out over the last few decades have taught us a lot, especially with respect to species for grazing management, fluctuations in grazing intensity and the availability of food. These aspects are much more important in achieving the desired grazing result than we initially thought. People have also started to accept grazing as a natural part of ecosystem dynamics. This new knowledge gives us the confidence to pursue changes in nature management as a whole, in particular with respect to the size and demarcation of nature areas. However, we must continue to expand our knowledge, especially with respect to population control.

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'QUATERNARY PARK': LARGE HERBIVORES AND THE NATURAL LANDSCAPE BEFORE THE LAST ICE AGE

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The blockbuster movie 'Jurassic Park' gave an impression of what the world might have looked like in the age of dinosaurs. In this article, we contemplate the natural landscape of the present geological age, the quaternary period.

Let's first go back to the epoch before the last Ice Age, when a truly natural ecosystem still existed in all of Europe. This is generally referred to as the last natural ecosystem, since man is held responsible for the extinction of many large animal species during and shortly after the end of the last Ice Age. Some researchers claim there is clear evidence of a prehistoric 'overkill' of mammoths, rhinoceroses, wild asses, giant deer and others. Therefore, the natural landscape of Europe after the last Ice Age cannot be reconstructed but has to be constructed by looking at areas in Africa and southern Asia where large plant-eating mammals still occur more or less in their natural proportions, or by studying Europe's own ecosystems in past interglacials. It is important to gain more knowledge of the truly natural landscape in Europe, particularly with respect to the circumstances which have influenced the evolution of the plant and animal species that we have today. Since ungulates have always played an important role in natural ecosystems, policymakers and nature managers cannot afford to ignore the importance of truly natural grazing.

The spectrum of large herbivores species

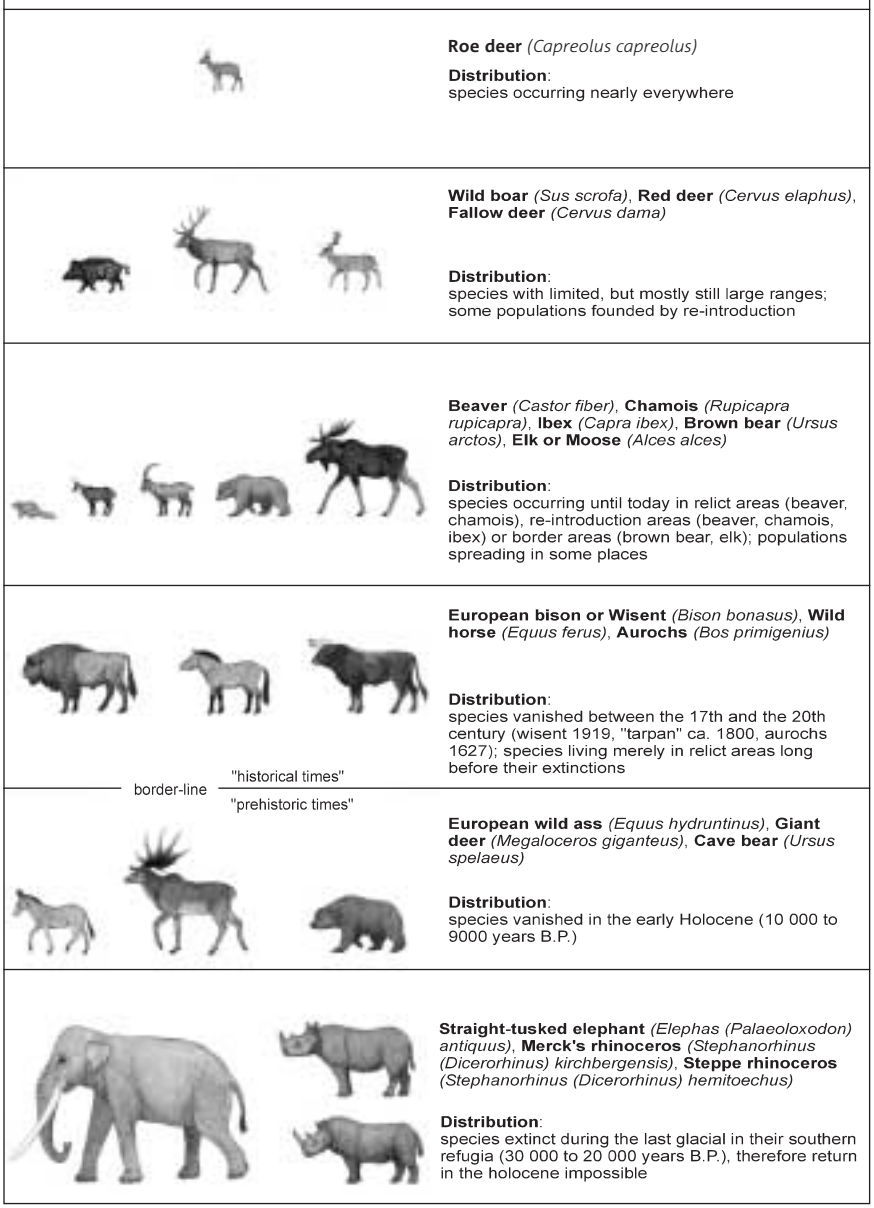
Figure 1 depicts the large herbivores which we expect would live in a typical interglacial. Most of these eighteen species would probably be found throughout central and western Europe. Only three species (chamois, ibex and European wild ass) are unlikely to occur in north-western Europe. There are five more species that might have to be added to the list in figure 1, but as yet we have insufficient evidence of their former distribution. These are the porcupine, which was found in central Europe during the last ice age but not during the last interglacial, the hippopotamus and the European water buffalo, which might occur in river valleys with a moderate climate (such as the Rhine valley), and mammoth and reindeer, which might migrate to central and western Europe from the north and east.

Different large herbivore species have different effects on the landscape, and these effects come about in different ways. The following species have the greatest influence on the landscape:

- megaherbivores such as straight-tusked elephant, Merck's rhinoceros and steppe rhinoceros because of their body size, mechanical might and enormous food intake;
- specialized grass-eaters (grazers) such as aurochs, wisent, horse, wild ass and steppe rhinoceros which create and maintain grassland and whose dietary requirements thus turn around or stop normal vegetational succession;
- species which live in herds or fairly large groups such as ibex, red deer, aurochs, wisent, horse and wild ass and thus exert a high grazing intensity;
- beavers which can divert watercourses, create beaver meadows and start the process of peat formation.

Not all groups of species still occur in north-western Europe. Megaherbivores

Figure 1. Typical interglacial large herbivore fauna of central and north-western Europe, classified according to the size of their present range respectively the time of their disappearance.



are of course extinct here, and the ecological niches of typical grazers in open and semi-open landscapes are vacant, except for the non-native mouflon which has been successfully introduced in a few restricted areas.

Natural populations and limiting factors

What would be the population density of large herbivores in a "Quaternary Park" and how would these populations be regulated? Food availability and predators are generally the most important regulating factors. Disease and parasites rarely have a significant influence. Unlike Africa, Europe has severe winters when food is scarce and populations of wild animals can suffer considerable losses. On the other hand, native herbivores have adapted their body structure, physiology and behaviour remarkably well to the average winter climate. Adaptations include growing a winter coat, storing fat reserves, changes in diet, migration, hibernation (bears) and building food supplies (beaver).

Studies in Africa have shown that the population density of megaherbivores such as elephant and rhinoceros is regulated solely by food and water. It is not known whether the sabre-toothed tiger had an additional effect in similar herbivore communities in Europe.

The population size of migratory species is also determined solely by the presence of food and water. In the interglacial epochs, herds of horse, reindeer, perhaps wisent and to some extent red deer roamed Europe. Migrations may help to make the best use of the food supply, but may also help to avoid predation. Many predators are territorial and do not travel long distances with their young.

In Africa, populations of animals which do not migrate are regulated in part by predators. In a typical central European interglacial, the following large predators should be expected: wolf, brown bear, lynx, lion, leopard and cave hyena. Their prey includes ungulates with more or less fixed territories: wild boar, fallow deer, roe deer, chamois and probably aurochs. Predation probably influenced grazing and browsing intensity, but did not change the importance of herbivory in shaping the landscape.

Effects on the landscape

Research in southern Asia and especially Africa has shown that megaherbivores and herds have a strong influence on both the landscape and the occurrence of other species. There is ample paleontological evidence that such herbivores also lived in prehistoric times in central and north-western Europe. In our region, they probably played a key role in various natural ecosystems.

There is strong evidence that forest vegetation in past interglacial epochs was much thinner and more open than in the period after the last Ice Age. The typical interglacial landscape in central and western Europe probably consists of a rich temporal and spatial mosaic of forest and steppe and all the stages in between.

The East African savannah is the best example of a half open landscape with a complete population of large herbivores and large-scale seasonal migration: Tsavo National Park in Kenya. Photo: M. Hölker.

Examples of natural landscape entities are:

- Floodplains with alluvial forest, bare ground, reedbeds and water meadows. This landscape is maintained by beavers, and possibly by hippopotamus and by other species which come to drink there.
- Semi-open landscapes of which today some relicts remain as park-like 'pasture woodlands'cover large areas of flat and hilly terrain.
- Expansive open areas. It is possible that these develop as a result of grazing, especially on dry or shallow, fertile soils. Forest associations on such soils do not hold up well against grazing and browsing.
- Other open areas which are not wooded for reasons of soil, hydrology or climate; such as bogs, rocks and salt marshes. The appearance of these landscapes would not be much affected by the presence of large animals.
- Tall forests situated in areas which are not attractive or dangerous for large herbivores, for example, deep but wet soils, steep slopes and nutrient-poor soils. Plants growing on nutrient-poor soils have a lower dietary value and have often developed chemical defences against herbivory.

The general spatial pattern of ''Quaternary Park'' could bear some resemblance to today's cultivated landscape: open areas on naturally fertile, dry soils, a fair amount of forest on low-nutrient sandy soils, on highlands and mountain ranges, and semi-open park-like landscapes on moderately fertile, fairly moist soils.

Besides creating a varied landscape spatially, grazing also contributes to the development of the landscape over time. In the natural landscape of Europe, grazing intensity fluctuates strongly over time depending on:

- Seasonal and irregular migrations of animals;
- Epidemics, severe winters, droughts and so on which temporarily decimate herbivore populations;
- Presence of predators in certain areas for certain periods of time, leading to a decrease of grazing pressure in that area;
- Overgrazing of grassland, reducing the incidence of fire and promoting growth of shrubbery;
- Fire, improving the structure and quality of vegetation for herbivores.

By the time the current interglacial epoch started 10,000 years ago, megaherbivores such as elephant and rhinoceros had become extinct, and some other large animal species were rare.

Unlike in previous interglacials, forests could now grow into tall, densely shaded forests consisting of a limited number of species. Because of methodical problems, it is hardly possible to draw conclusions about forest expansion, the size of open spaces in forests and the density of forests from pollen analysis. Elsewhere in this issue, Vera claims that populations of surviving ungulate species, especially the grazers aurochs and horse, were big enough to maintain a semi-open park-like landscape.

Grazing and the beech

The above also explains why beech is so dominant in remnants of pristine forests in central and western Europe. The beech, which is easily damaged by browsing and fire, did grow here and there during past interglacial epochs, but did not play a significant role in those landscapes, despite circumstances being similar to those of today. Perhaps elephants and other mammals, in combination with fires, prevented the beech from acquiring dominance in ancient forests. Humans probably facilitated the distribution of the beech by exterminating some large herbivore species at the end of the last Ice Age and by spreading beech seeds. According to this hypothesis, the beech owes its dominance in the forest these last 3,000 to 4,000 years to man, at the expense of oak, elm, lime, ash, maple and alder.

Possibilities for the future

Grazing and browsing by wild herbivores is an important process in natural ecosystems. A truly natural landscape is probably dynamic in both the temporal and spatial sense, featuring all stages of succession from forest to steppe. Because six of the eighteen large herbivore species that originally occurred in central and western Europe are now extinct, a full restoration of natural systems is unlikely. But despite the missing species, a near-natural system with the twelve surviving species would still resemble nature more closely than a system without these species. Among the surviving herbivores, all feeding types are still found, if cattle and horse

are included. So most ecological niches in the interglacial ecosystem can still be filled. This greatly increases the chances of a successful restoration of ecosystems containing habitats for most species of the native flora and fauna, including the species of open landscapes. What is most important is that nature areas are sufficiently large and that different species of large herbivores occur side by side.

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A PARK-LIKE LANDSCAPE RATHER THAN CLOSED FOREST

Frans W.M. Vera

The conventional view of 'prehistoric nature' may be incorrect. Rather than closed forest it may have been a park-like landscape in which large herbivores played a crucial role. According to this view, grazing does not constitute a threat for natural rejuvenation, but in fact promotes this process.

The prevailing view of nature in the European lowlands, before man's intervention, is of dense forests. In these forests, rejuvenation would have depended on openings in the forest canopy, caused by trees that had died or blown down. Here, sunlight streamed on to the forest floor, and seedlings became trees. This process is called natural rejuvenation.

If this view is right, then all our native trees and shrubs, species which we know occurred in the prehistoric landscape, should be able to survive without help in naturally developing closed forests. Analyses of pollen found in peat layers created during thousands of years have confirmed the existence of elm, ash, lime, oak, hornbeam, beech and hazel in prehistoric times. These are all wind-pollinated species. Pollen researchers hardly ever find evidence of insect-pollinated species such as wild cherry, wild apple, wild pear, hawthorn, sloe or the various types of rose.

One method of testing these species' abilities to survive in closed forest is to follow natural developments in forest reserves where these species now occur side by side. And the remarkable thing is that oak and hazel do not naturally rejuvenate in forest reserves in the lowlands of central and western Europe. These light-dependent species lose out to species that do well on shady sites, such as elm, ash, lime, hornbeam and beech. This contradicts the findings of pollen research. Oak and hazel do rejuvenate successfully in more open terrain grazed by large herbivores such as cattle and horses, especially when surrounded by thorny shrubs (juniper, rose, blackberry, hawthorn and sloe), or shrubs which do not have thorns but which are unappetising to herbivores for other reasons like heather and broom).

All this information forces the question as to whether this type of vegetation does indeed reflect the prehistoric vegetation of lowland Europe. If that is so, then the livestock that helps shape and maintain these park-like landscapes today in combination with wild ungulates like deer, must be considered as modern analogues of these the fauna of wild ungulates that was present in prehistoric times . Their diet and feeding habits underscore this theory. Being a descendant of the aurochs, the wild progenitor of our cattle, today's domesticated cow can be considered as being not much different from the prehistoric bovine animal. This goes for our domestic horses as well. They are in essence domesticated tarpans, the wild progenitor of the domestic horse that lived here during prehistoric times. In addition to these, non-domesticated species such as roe deer, red deer, moose and European bison roamed these prehistoric park-like landscapes.

Open areas are crucial to tree rejuvenation

Contrary to popular assumption, in park-like landscapes young trees grow outside forests, not in them. Young trees need open terrain, where vegetation is cropped short by large grazing animals such as cattle or horses. As well as oak and hazel, this open terrain also suits shade-tolerant species. On richer soils, where sloe may grow, new trees grow in the peripheral vegetation on

A new theory kicking up a dust.

the edge of the forest formed by the mantle and fringe vegetation. Every forest originally started out as a few trees growing in a thorny copse. Sloe reproduces itself by putting out rootstocks. Seedlings, especially oak, continually rise up in copse margins because jays commonly plant acorns there.

The jays' habit of planting acorns is not restricted to the margins of a copse, thorny or otherwise. They also plant them in the zone between short and long grass. This explains why young oaks are found scattered in open grassland. Jays also have a marked preference for minerals-rich soils, such as those worked by wild or domesticated free-range pigs. Hawthorn and sloe also grow well there. Grazing rids open terrain of tree seedlings, except those protected by unappetising copse. Thorny shrubs are as effective as barbed wire in protecting young trees from hungry mouths. Eventually the trees grow so big that they form a closed canopy, under whose shadow the shrubs die until only peripheral vegetation remains around the group of trees. This is then a grove. The mantle and fringe vegetation is called the hedge.

In woods, rejuvenation is made impossible by shade and the presence of large herbivores. When a group of trees is felled by storm, old age or sickness, light streams through the hole in the canopy on to the forest floor, where soon herbs and grasses grow. This vegetation attracts large grazing animals, so that any tree seedlings reckless enough to locate in the clearing invariably get eaten. Over time, the wooded terrain slowly changes to grassland, a transformation that may be accelerated by drought, storm or fire. Ultimately, the terrain becomes open grassland, where thorny shrubs grow, followed by new trees. A site is thus successively grassland, copse, woods, grassland, copse, woods and so on.

Natural grazing ensures cyclic succession

The process described above is not a new discovery. Everyone is familiar with aspects of it, such as the invasion of grassland by shrubs and trees, or the decline of woodland due to grazing. But most people do not see these subprocesses as part of a larger system. On the one hand, many people see the invasion of trees in grassland as evidence that a terrain cannot be kept open by grazing. On the other hand, people blame grazing for the degeneration of woods to grassland or heath.

I would like to stress one thing; grazing, that is natural grazing rather than agricultural grazing, always has a constructive role in the establishment of trees and shrubs. A policy of of natural grazing should, therefore, never be adopted with the aim of keeping a certain site open. On the contrary, it will ultimately result in afforestation. At the same time, however, natural grazing always ensures that existing woodland gradually evolves to more open terrain. In other words, grazing will only result in open terrain if grazers are allowed to change woodland to open grassland by preventing the rejuvenation of trees. I use the word 'allowed' deliberately here because eco-

Natural grazing aids cyclic succession: open terrain becomes closed woodland, bordering woodland 'degrades' to open terrain.

logists, foresters, site managers and politicians often oppose this process. After all, we've all grown up with the idea that closed forest was the most natural vegetation for this part of Europe and that trees should regenerate within the forest. Thus, woodland grazing is only allowed provided the woodland is maintained. The result of this policy is; grazing experiments in woods with animal densities that are far too low.

The question is, which densities would be more effective? It depends, of course, on soil type. Richer, more productive soils can bear more animals than poor sandy soils. The so-called saturation density, reflecting the number of animals that can live year-round in their natural biotope, should be used as a guideline in deciding grazing densities. Achieving the right balance tends to be a matter of trial and error. I am certain, however, that grazing densities will turn out to be much higher than people now think, because the prevailing view is that existing woodlands should be preserved.
Historical data from the Forest of Dean and the New Forest show that successful woodland rejuvenation occurred with the following mix of large herbivores: one cow per 4 - 4.5 hectares, one horse per 9 - 15 ha, and one deer (fallow deer or red deer) per 3 - 3.5 ha. The deer density alone was more than ten times the figure that foresters and forest ecologists considered the limit for successful rejuvenation.

Why this enormous discrepancy? The explanation lies in the fact that rejuvenation does not take place on the same site as the old woods. In grazed park-like landscapes like the Forest of Dean and the New Forest, rejuvenation with the above grazing densities occurred outside the woods, in sunny copses of hawthorn, sloe and holly. Foresters' density figures are based on rejuvenation in clearings in the woods. In park-like landscapes however, rejuvenation is made impossible in such clearings; the woods must first transform to open terrain where young trees can grow in thorny copses. Many open minds will be needed if we are to achieve this in Dutch and other European woods!

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