Overutilization of Pastures by Livestock

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SUMMARY

Soil degradation caused by overgrazing is a worldwide problem. The degradation of an overutilized area occurs mainly where animals prefer to spend extra time because of the attractants that are around gateways, water sources, along fences or farm buildings. High grazing pressure decreases plant density which results in changes of the botanical composition of a pasture. The effect that grazing has on a plant depends on the timing, frequency and intensity of grazing and its opportunity to regrow. Overgrazing adversely effects soil properties, which results in reduced infiltration, accelerated runoff and soil erosion. Evidence has been corroborated with high bulk density values, high dry mechanical resistance and low structural stability. The degradation of the landscape may be a short-term phenomenon and recovery is possible after grazing pressures have been greatly reduced. Management practices have been used successfully to improve grazing distribution. These practices include water development, placement of salt and supplements, fertilizer application, fencing, burning, and the planting of special forages which can be used to enhance grazing by livestock in underutilized areas.

The authors carried out their grazing experiment on the Hortobágy. The effects of overutilization by livestock on soil properties and vegetation on certain areas of grassland are presented in this paper.

Keywords: *overutilization, soil, vegetation*

Overgrazing is considered to be the major cause of soil degradation worldwide (Oldemann et al., 1991), accounting for 35.8% of all forms of degradation. However, degradation caused by overgrazing is especially widespread in Australia and Africa, where it accounts for 80.6% and 49.2% respectively of all soil degradation, and least extensive in Europe (22.7%) (Warren and Khogali, 1992).

There are some explanations of overgrazing in the literature, but these differ in approach.

One UK regulation considers only the vegetation: overgrazing means grazing land with livestock in such numbers as to adversely affect the growth, quality or species composition of vegetation on that land to a significant degree (Statutory Instrument, 1996).

Wilson and MacLoad (1991) include animal performance as well, they state that a grassland is overgrazed where a concomitant vegetation change and loss of animal productivity arises from herbivores' grazing of land.

Overgrazing can mean different things to the grazier and the range manager. For the grazier, it implies that the pasture can no longer carry as many animals as before, or that its productivity has declined so that the performance of the animal either in terms of liveweight gain or offspring reproduction has worsened. To the range manager therefore: the carrying capacity of a pasture or range is the number of animals of a specified type that can subsist on a unit area and produce at a required rate over a specified period, usually a season, a year, or longer. An optimum stocking rate allows grazing animals to produce at the most economical rate (Cowlishaw, 1969).

The fact that overgrazing is not a function of animal numbers, but rather a function of time, has to be emphasized. Overgrazing occurs when animals are kept in a paddock too long or brought back too soon, the latter means that a plant is grazed before it has recovered from a previous grazing (Pratt, 2002).

LIVESTOCK DISTRIBUTION ON PASTURE

In connection with overgrazing, the most important factor resulting in range deterioration is poor livestock distribution. Poor distribution of livestock impacts lead to the overutilization of some parts of the range and overresting of others. Areas that are overutilized (too much forage removed) often have most of the forage plants overgrazed (grazed too frequently) as well. On the other hand, improving grazing distribution by livestock is an effective tool for improving watershed condition and reducing erosion (Kauffman and Krueger, 1984). Domestic livestock are creatures of habit. They show the following behaviour characteristics:

- loitering at water access points, especially in shaded riparian areas,
- limited use of upper slopes and higher elevations,
- preference for particular vegetation types,
- preference for previously grazed areas.

Improving stock distribution is one of the predominant goals of all grazing systems (BCMF, 2002). However, in several countries, the movement of a herd on a certain pasture is not strictly controlled, which means that animals can freely graze and utilize the pasture (Molnár and Jávor, 1997). The results of poor distribution are paradoxical, overgrazing and overresting occur in the same pasture (BCMF, 2002).

Grazing distribution patterns of large herbivores are affected by abiotic factors such as slope and distance to water and by biotic factors such as the quantity and quality of forage. Abiotic factors are the primary determinants of large-scale distribution patterns and act as constraints within which mechanisms involving biotic factors operate. Usually, there is a proportional relationship between the time that large herbivores spend in a plant community and the available quantity and quality of forage (Bailey et al., 1996).

Several management practices have been used successfully to improve grazing distribution. For example, water development (Valentine, 1947; Cook 1966), placement of salt and supplement (Cook, 1967), fertilizer application (Hooper et al., 1969), fencing (Bailey and Rittenhouse, 1989), burning, and plantings of special forages (BCMF, 2002) can be used to enhance grazing by livestock in underutilized areas. Spreading the use of grassland forage across the pasture is also a tool which usually prevents the heavy utilization associated with concentrated grazing (Bailey and Rittenhouse, 1989). These practices have been successfully used to prevent uneven grazing distribution, however, their use is limited. Fertilization is expensive, and the benefits are only short-term (Hooper et al., 1969). Water developments and fencing would need extra financial efforts and may be impractical.

The placement of supplements is supposed to be an appropriate tool for modifying grazing distribution (Valentine, 1990; Bailey et al., 1996). McDougald et al. (1989) found that the use of riparian areas dropped dramatically when supplement feeding sites were moved to areas that were previously underutilized.

Bailey and Welling (1999) state that cattle spent more time and grazed more forage in pasture areas where molasses supplement was provided than in similar control areas where no supplement was provided. Although it was more effective in moderate terrain (10–20% slopes), the strategic placement of supplements noticeably changed livestock grazing patterns in steeper terrain (15–30% slopes) at greater distances from water. Consequently, placing molasses supplement in underutilized rangeland can improve the uniformity of grazing by cattle. However, it should be mentioned that this approach was effective only when the supplement was moved regularly.

Bailey et al. (2001) measured the effective range of supplement. They concluded that when dehydrated molasses supplement was placed in rugged foothills rangeland, cattle grazed nearby areas relatively evenly for distances of 0 to 600 m from the supplement. If the distance was greater than 600 m, the forage use declined linearly with increasing distances. The authors noticed that the use of supplement may not be effective if cattle are not exposed to the supplement before it is placed in the rangeland.

Herding can be used to reduce the concentrations of animals and turning out the livestock to areas formerly receiving less use (Skovlin, 1957). Hart et al. (1993) showed that decreasing the pasture size and reducing the distance from water were more important for improving forage utilization patterns than for implementing intensive rotational grazing systems.

Overutilization of riparian areas may be alleviated by attracting animals to other forage sources during the critical periods. The habits of the cattle managers are often hard to break. Farmers place salt and minerals near water access points and streams to make them readily available to stock. By using attractants to distribute livestock, better utilization of pastures can be achieved while simultaneously relieving grazing pressure on preferred areas. Attractants can also be used to create and apply „herd effect" as a tool (BCMF, 2002).

EFFECTS OF OVERGRAZING ON VEGETATION

Botanical composition of the pasture is influenced by the joint effect of several environmental factors. In an experiment, Jones and Bunch (1995) found that the spread of a specific plant species was more affected by the annual precipitation than by the presence of animals.

Grazing animals also have an effect on the botanical composition by trampling and selective grazing. Furthermore, animal faeces and urine change the element content of soil and plants. Species composition is also influenced by the time of the year that a pasture is grazed. Hyder et al. (1975) pointed out that repeated heavy grazing during any particular month in the growing season had approximately three times higher effect on key species as did grazing during the months when plants were senescent.

The way that a plant community responds to a specific grazing pressure depends on the season effect. The area covered by Desmodium spp. decreased as the stocking rate increased, however, the same conditions did not have the same effect in the next year (Aiken, 1990).

Moreover, high grazing pressure decreases plant density. However, this may not decrease the total plant production of a given community, because the roots of other plants may simply occupy that space in the soil. These other plant species are often less productive and less palatable, often weedy forbs and brush, which would result in decreased animal productivity (PAI, 2004).

According to Pratt (2002), it is important to notice that weeds do not make the land unhealthy, they appear because the land is unhealthy.

Possible positive effects of grazing include the removal of dead growth, the opening of the canopy to allow earlier soil warming in the spring, the decreased moisture losses from the plant, the removal of some older leaves that may be infected and the intercept of significant amounts of rainfall (PAI, 2004).

High grazing pressure changes the botanical composition of the pasture (Jávor, 1999). Török and West (1996) studied the influence of marked population growth of mouflon on the vegetation composition of 7 rock grassland communities by re-sampling after 30-50 years. The results showed environmental degradation of the communities: the presence of protected plant species decreased and that of degradation indicators increased. The rate of degradation depended on the type of the substrate.

Brizuela and Cid (1993) stated that the first signs of overgrazing were a decrease in legumes and an increase in forbs and in bare soil. Similarly to overgrazing, the lack of grazing also has negative impacts on pastures of continental climate, for instance it entails the spread of weed and shrub species (Jávor et al., 1999).

In an experiment of Longhi et al. (1999) species number was higher within ungrazed, fenced areas or areas where topography provided protection from grazing. Moreover, species number was correlated with herbage height, which is an indicator of grazing intensity. On the other hand, Paulsamy et al. (1987) found that both protected and grazed sites had equal numbers of species with different floristic composition. Intense grazing destroyed a few palatable annuals and overgrazing favored the invasion of certain unpalatable annuals such as Amaranthus spinosus. If these species remain unchecked, they could be dominant in due course and alter the pasture value of the grassland.

Fuls (1992) claimed that long-term patch-overgrazing induced substantial vegetation retrogression with reductions in basal cover up to 90%. Within severely degraded patches, the basal cover was sometimes <1% and the species present were predominantly low successional status annual and pioneer grasses.

According to Arianoutsou et al. (1985), in the absence of grazing pressure the plant cover was 30% trees, 10% tall shrubs and 25% sub-shrubs. Under high grazing pressure the plant cover was mainly low woody shrubs.

The grazing of a cattle herd was investigated in our experiment on the pasture of Hortobágy. Bare soil was found at overutilized areas, such as camps for rest, water and salt sources. As a result of the fact that the camps were not moved approximately for one decade the area covered with no vegetation extended to 0.1 hectares. Plant species at the bank of overutilized areas were grazing tolerant, not native and not typical of the land, such as Lolium perenne, Polygonum aviculare and Chenopodium album.

EFFECTS OF OVERGRAZING ON SOIL PROPERTIES

Increased livestock numbers in arid regions cause overgrazing which results in reduced infiltration and accelerated runoff and soil erosion. Results of several studies (in Argentina and India) indicate that at the macro- and mesoscales soil erosion can increase dramatically due to overgrazing, causing increases of 5 to 41 times over the control at the mesoscale and 3 to 18 times at the macroscale (Sharma, 1997).

Villamil et al. (1997) pointed out that inappropriate cattle grazing practices, such as overgrazing harm the quality of natural pastures and soil properties. The soil structural degradation in the upper horizons are approved by high bulk density values, high dry mechanical resistance and low structural stability in comparison with the climax situation.

Soil and sward are in close connection, which determines the changes in soil physical, chemical and microbiological properties. This fact is especially true in areas where animals are grazed for a long time (Kátai, 2003). Grassland soils usually have extreme physical and chemical properties as well. Soil microorganisms play a significant role in developing soil fertility. The dominant characteristics influencing the existence and activity of soil microbes are soil water content and storing capacity, texture, size and rate of pores (Kátai, 1994). However, treading may decrease habitable pore space and increase soil bulk density, which negatively affect soil microbes (Kátai, 1998).

Zhang et al. (2001) stated that heavy grazing can cause grassland deterioration because of heavy defoliation and treading, and is often used for weed control. Sheep Night Penning, a form of heavy grazing, has developed into a successful method of removing the native vegetation and establishing a new pasture. Results show that high sheep density for a short duration removes almost all of the above-ground natural vegetation, but does not significantly affect the soil bulk density, the penetration resistance, and the air permeability. Jiang et al. (1996) also found that sheep nigh penning combined with grazing has eliminated the natural vegetation containing shrubs. The removal of natural vegetation is caused by the fact that the concentrations of ammonium-N and nitrate-N in the soil were high enough to be toxic to plant roots during and after sheep night penning (Zhang et al., 2001).

Abril and Bucher (1999) measured the changes in soil characteristics, nutrient availability and microbial activity on sites utilized by different grazing intensities in Argentina. Three sites were selected for comparison: a highly restored (no grazing for 20 years); a moderately restored (8 years of restoration); and a highly degraded (extremely overgrazed). The following parameters decreased as the grazing intensity increased: the soil moisture (4.5 to 2.25%), the organic matter (4.68 to 1.45%), and the nitrogen content (0.28 to 0.14%). Microbial activity ranged from 0.89 at the restored sites to 0.22 mg CO_2/g/week at the highly degraded site. The seasonal variations in the density and the activity of microorganisms increased from the highly restored to the highly degraded site, probably as a response to an increased lack of humidity. The cellulolytic and nitrifier groups were the most affected, whereas the ammonifier and free-living N-fixing organisms decreased in the highly degraded site only. N fixation was more intense at the moderately restored site followed by the highly degraded site. The observed values are interpreted as resulting from the interaction between organic matter availability (as energy source) and N deficiency. The results suggest a strong influence of overgrazing on the soil fertility, as well as on the soil ability to buffer water stress during the dry season.

According to LingHao et al. (1997) an average of 12.4% of the total carbon initially stored in soils (0-20 cm soil layer) has been lost due to overgrazing over the 40-year period. Most carbon loss was from the active and the slow soil carbon pools which had a residence time of decades. In another experiment, Abril and Bucher (2001) compared the same three situations (highly restored, moderately restored and highly degraded) again. Results demonstrated that the organic carbon and the CO_2-C values decreased from the highly restored to the highly degraded, whereas the C mineralization rate increased toward the less restored sites. Surface-litter C was similar in both sites under restoration being non-existent at the highly degraded site. The magnitude of the between-season differences was the highest at the highly degraded site (in soil organic carbon, in CO_2, and in C mineralization rate).

Villamil et al. (2001) claim that topsoil horizons show a reduction in depth in grazed sites, mainly as a consequence of soil compression caused by animal hooves. They found that total porosity values in the top few centimeters are lower in grazed sites, primarily due to the collapse of macropores (>50 µm) and larger mesopores (50-9 µm). Water retention curves for the three depths in the different patches reflected the changes in pore space distribution. Results indicate that grazing causes a sharp increase in mechanical impedance in the first 10 cm of soil. Moreover, there are marked differences in the degree of aggregation in grazed sites compared with ungrazed sites. The former shows a lower quantity and density of roots in the top few centimeters of the profile. Changes in average root diameter as a result of vegetation substitution brought on by overgrazing are also evident.

Evans (1996) observed that degradation occurred mostly along fences where often more than half the soil was exposed to trampling and weathering. Similarly, Moles (1992) described that bare soil is commonly found along tracks, for example around gateways or farm buildings where animals concentrate. Most bare soil, sometimes referred to as 'sheet erosion' (Whitlow, 1988) is created by sheep at small breaks of slope where they initiate scars by rubbing against the vegetation (Evans, 1977). Scars have been extended by the constant disruption of the soil surface by hooves, being used not only as scratching posts but also for shelter, so that vegetation cannot colonize and stabilize the surface (Evans, 1977). Tallis and Yalden (1983) also noted in their study that in case the soil surface is continually disturbed by animals during the growing season, the seedling germination and the invasion by plants is inhibited. Moreover, Evans (1977) claimed that sheep scars were disturbed disproportionately more in summer than in winter, thus hindering the revegetation of the bare soil**.** During the winter, frost-heave disrupts the surface, preparing it for further erosion by wind and water (Evans, 1990).

Factors controlling the existence and location of bare soil include grazing intensity, topography and sward type. Thomas (1965) pointed out that scars can be initiated at summer grazing intensities of 0.2-0.4 ha per sheep (on steeper slopes of more than 15º, often more than 25º with a good grassy sward), Evans (1977) observed bare soil when the year-round grazing intensity was 0.5-0.6 ha per sheep and the summer grazing pressure reached 0.1 -0.3 ha per sheep. Moreover, Evans (1992) found scars at the intensity of about 2.0 ha per sheep on susceptible soil types. Grant et al. (1985) experienced a rapid increase in the area of bare soil at a grazing intensity of 0.4 ha per sheep. On grassy slopes where scars were most extensive, summer grazing pressures were 0.2-0.4 ha per sheep (Carr, 1990). Evans (1997) claimed that where reindeer grazing confined by fencing or topography, degradation thresholds were lowered and peaty and mineral soils began to erode on slopes as low as 4°.

According to Thomas (1965), scars can be found where the underlying mineral soils were often shallow and freely drained weathered rock or stony head, scree, or till. Evans (1996) state that scars are present most likely in wet peaty hollows; on slopes steeper than 7° where soil were peaty or 13° where they were mineral-based; at the edge of terrace landforms or where drumlins occurred; and especially where deep sandy soil occurred.

Sward type is also an important factor controlling the location of bare soil. For example, scars appear to form most easily in moorland acid grassland swards containing a high proportion of wavy hair grass (Brunstrom, 1976), and less readily in other moorland vegetation types. This is because these swards are more nutritious and attractive as resting places than other moorland vegetation types (Carr, 1990).

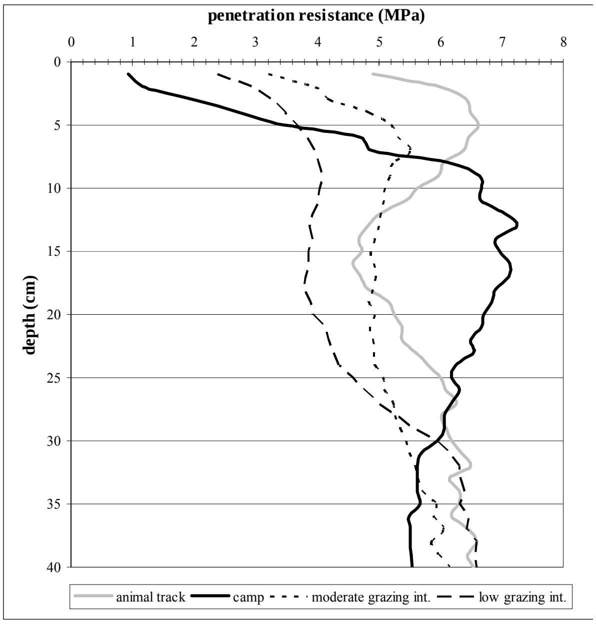
Some soils or subsoils, once exposed, are so unstable and erodible that vegetation cannot easily take hold. Peat is the example of the former (Large and Hamilton, 1991), shales, scree or loose sand of the latter. Lowland improved pastures are more resistant to sheep scar formation, probably because these grasses give a denser and more vigorous cover and have better rooting systems.

Free range grazing of Hungarian Grey Cattle resulted in an uneven grazing distribution at our experimental grassland. The animal density on the pasture was adequate for forage yield, although differences in utilizations made some parts of the pasture overgrazed. Soil $pH_{(H2O)}$ of the upper layer increased as grazing pressure was higher (5.7 at moderate grazing and 7.3 at camp sites). Urine was the main excreta which caused significant changes in the salt content of soil. These were 0.033% and 0.317% at moderate and overutilized sites, respectively. Nitrate- and ammonia-nitrogen were found in higher concentrations at the soil of the camp sites (34.1 and 12.2 ppm, respectively) than at other parts of the grassland (2.5-3.2 and 3.4-4.7 ppm, respectively).

Our statement on soil carbon and nitrogen concentrations appear to contradict those found in literature, however, it originates from different types of overutilization. An overutilized area of pasture can be overgrazed where the plant biomass decreased or a special part of the land, normally with a smaller extent, where animals prefer to spend extra time because of its attractants such as water, salt or shelter. The latter is covered by vegetation to a

smaller degree. Most papers refer to the fact that the soil fertility of overgrazed sites decreases. Our results indicate higher soil nitrogen and carbon concentrations of the upper layer at animal camps (3520 ppm, 4.12%) comparing to sites grazed with moderate grazing intensity (2413 ppm, 2.91%). We suppose that animal urine and faeces are deposited in such a quantity that increased soil fertility.
Soil penetration resistance was determined at low and moderate grazing intensities, at animal camp and along tracks (*Figure 1*). Results show little differences between the low and the moderate utilization. In contrast, penetration resistance significantly differs at the camp and along tracks. Animal trampling induced soil compaction on pathways which are used usually for one year and cows are walking on this way in single file. This compaction disappeared at the depth of 10-15 cm. Curve of soil penetration resistance at the camp had a special shape. The soil was extremely light at 0-4 cm that indicates the moving activity of hooves and it was followed by an increasing compaction in deeper layers, which reached a maximum of 13-17 cm.

Figure 1: **Soil penetration resistance at sites utilized by different intensities**



TOOLS FOR PASTURE REMEDIATION

The degradation of the landscape may be a short-term phenomenon and recovery is possible after grazing pressures have been greatly reduced. This occurs because animal populations crash as the vegetation cover is grazed out. This phenomenon can also be found in cold climates where, for example, reindeer have been introduced and thrived until their preferred forage has become grazed out (Leader and Williams, 1988). BCMF (2002) categorized the tools for managing overutilized grasslands (*Table 1*).

Pratt (2002) suggests to farmers to move livestock out of a pasture before regrowth begins to prevent pasture land from overgrazing. During the periods of fast growth, overgrazing will occur if livestock are kept in a paddock for more than three or four days. Equally important is that animals should not be turned out to pasture before plants have recovered.
Overgrazing can be stopped with 8-10 paddocks. When the plant growth is fast, recovery periods of four to six weeks may be adequate. This means that eight to ten paddocks will result in graze periods of about four days. When shorter graze period and/or longer periods are necessary for the plants, 15-20 paddocks or more are often needed.

Anderson and Radford (1994) monitored the effectiveness of shepherding for eight years as a mean to secure the revegetation of eroding grounds without the expense of fencing, or supplementary treatment with seed or fertilizers. Grazing pressures were reduced from about 0.4 ha per sheep to 5.6-2.3 ha per sheep, and over eight years the average plant cover increased from 49 to 91.7%. However, whereas on the mineral soils of the lower slopes vegetation cover of 90% was achieved in five years, on the higher very steep slopes (30º) 24% of the surface remained bare until the end of the experiment. On the gentler (11º) slopes, plant cover was almost complete by the end of the experiment.

Table 1

Tools for pasture remediation (BCMF, 2002)

Grazing Management	Applied Disturbance	Rehabilitation Treatments	Riparian Structures
Grazing and rest period	Prescribed burning	Seeding uplands	Bank stabilization
Class of livestock	Mowing and cutting	Riparian plantings	Channel modification
Season of use	Chemicals	Mechanical treatments	Fencing
Attractants	Scarification/ tillage	Mulching	Water developments
Herding	Biological control	Long-term rest	
Fencing	Animal impact		
Water developments	Herd effect		
Stocking rate, density			

Several studies were carried out about bioindicators of overgrazing. Read (2002) suggests reptiles as bioindicators of the initial effects of heavy cattle grazing in a South Australian chenopod shrubland. Paton et al. (1997) conducted a regression for usage of grasslands by cattle for Spanish environmental conditions in which a plant species (Plantago major) was used as a bioindicator.

CONCLUSIONS

Animal grazing is a natural process of forage utilization, because herbivores produce in the environment where evolution formed them. This is the most appropriate, low cost tool for meat production.

A significant portion of world grasslands are overutilized by livestock. Although a parcel of land is not overgrazed there are some parts where signs of degradation can be found. These special areas are attractive for ungulates because there are water, supplement and salt sources, camps or shelters. Overgrazing has detrimental effects on soil and vegetation but changes are reversible. High grazing pressure decreases plant density, changes botanical composition, and often accelerates the invasion of unpalatable species.

Moreover, overgrazing increases area covered by no vegetation, reduces infiltration, soil moisture and fertility, accelerates runoff and soil erosion, increases soil bulk density, penetration resistance, soil ammonia and nitrate content and changes soil microbial activity. Nevertheless, all these negative impacts can be prevented and/or reversed by proper grassland management practices.

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