RANGELAND MANAGEMENT

Pardini A.
University of Florence, Italy

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Summary

Rangelands sustain large numbers of livestock and are home to the largest number of wild grazers and browsers than are other environmental regions. They have, moreover, a fundamental importance to the survival and economy of many peoples, and play an important ecological role on a global scale. The ecological and economic importance of rangelands will be even greater in the future.

Unfortunately, the removal of vegetation for firewood and timber, and by animal overgrazing, has caused degradation of the productivity and biodiversity in extensive areas. There are various techniques that can be proposed to recover or improve the present quality of these ecosystems. Nevertheless, ordinary management can only provide temporary solutions, because the number of people living on the produce of the rangelands is increasing almost everywhere, as is the number of their livestock.

More comprehensive solutions will be necessary to preserve some of the rangelands, including an effective diversification of the forage resources and land use. Above all, it is essential to aim at the entire diversification of the local economies and their integration within a global perspective.

1. Introduction

The present conditions of the rangelands are the result of a protracted evolution of plants and animals, which has also been influenced by human activities for thousands of years. Unfortunately the impact of humans and their livestock became excessive and negative in the second half of the twentieth century. The removal of vegetation for wood and overgrazing are the main causes of the deterioration. Certain improvements have actually been made in some of the rangelands, but these do not make up for the serious conditions that have developed in more extensive areas.

Over 26% of Earth's land is now pasture or grazing land. This area increases to over 70% when only agricultural land is considered. These percentages are predominantly composed of rangelands, plus pastures and other types of grazing land. The area occupied by grazing land is in dynamic equilibrium with that of agricultural land and forests. Approximately 220 million hectares of forest became pasture in the thirty years between 1970 and 2000; this area, added to that of the previously existing rangeland, has brought the level of grazing land up to the present 3423 billion ha. Most of the new pastures emerged from the native forests of Africa, Asia, and America, and only a small part from the noncultivation of unproductive land. The abandonment of cropland has favored the new diffusion of pastures and rangelands, in some parts of Europe as a result of economic diversification, and in parts of Africa after population dispersal caused by both AIDS and war. In the same period, grazing lands have been lost as a result of acidification or salinization in Australia, and in Africa through desertification.

On the other hand, the number of livestock has increased by 600 million heads (equivalent to ~250 million livestock units (LU)) over the last thirty years of the twentieth century; the total number is at present ~3,300 million heads, half of which graze in the rangelands. This number is too high when compared to the area of pasture, thus ~30% of the total world production of cereals and pulses is necessarily used to feed some of these animals. Some of the livestock are housed in stables, but nevertheless the rangelands sustain most of the domestic livestock and are also home to the largest number of wild grazers and browsers. Excessive exploitation, due both to direct human intervention and to the unduly high number of animals, has frequently resulted in moderate to severe degradation in the quality and productivity of this ecosystem.

Traditionally, the principal parameter taken into consideration when estimating the value of a rangeland was its production of forage; however, its vegetation also contributes in other ways to the economy of the local population.

Animal products and by-products, firewood and timber, medicinal plants, wild fruits and honey—these are all part of rangeland-based economies. Moreover some new industries have already identified the economic importance of native forage: small legumes produce estrogens for the pharmaceutical industry, while other species can absorb the heavy and toxic metals produced by industrial activities and mining; genes are being collected to improve certain characteristics of the crops. This biodiversity will presumably be valorized in the future.

Rangelands also play a significant role in ecological stability on a global scale, and their importance also comprises landscape diversity over large territories. Biodiversity, landscape diversity, and economic differentiation interact and will influence future changes in the pastoral economies.

2. Rangeland Utilization and Degradation

The low population density and the primitive technologies available in the past meant that the rangeland capacity to support life remained almost unchanged for many centuries. The impact of humans on the native vegetation had only a minor effect, on a local and regional scale. Demographic growth and the availability of modern technologies during the 1900s have had a greater impact than that of the entire previous history. Throughout most of the world, the results have been decreased productivity and a deterioration in the quality of the ecosystems. The cutting down of trees and shrubs is always negative to the rangeland, although this ecosystem can tolerate rational utilization.

As a versatile instrument, the positive or negative effects of animals depend on management. Only an excessive number of animals is negative to productivity and biodiversity.

On the contrary, rational planning of the pastoralism can exert a positive influence on the conservation of the resources. The positive effects of moderate grazing by wild animals have been well known for many years, and more recently have also been confirmed in relation to domestic livestock and different climates.

Moderate grazing can stimulate plant productivity: the removal of older plant tissue provides a greater light intensity for the younger leaves, which enhances their photosynthetic potential. The number of plant species can be increased if the vegetation is grazed properly. Biodiversity can be enhanced by the presence of a balanced number of grazers or browsers, because the changes they provoke in the vegetation enable the simultaneous existence of species typical of different ecosystems. Naturally, moderate changes to the vegetation are reversible, and continual management is necessary to avoid a reverse trend in the new botanical composition. Grazing has been proposed in central Europe to balance the increased biomass production caused by the polluting nitrogen carried by rainfall, while sheep are used in the rangelands of northern Italy to crop the pasture. In both of these cases, the grazers are a means towards good land management; effectively, they prevent changes in vegetation in areas that have been pastureland for centuries and have reached an ecological equilibrium.

2.1. Effects on Productivity

Increase in the utilization of forage and wood go hand in hand: settled peoples depend on rangelands for game hunting and husbandry, but they also need wood to build huts, fences, and houses to keep warm and to cook. Forage availability favors population growth, and the new arrivals cut more wood and then also try to increase their livestock. If not kept under control, this mechanism can lead to desertification.

Initially, wood harvesting has a higher impact on the rangeland than grazing. Wood collection is more intense close to villages, where it causes reduction of the plant cover and local overgrazing. People and animals then move to more distant areas, so that the native vegetation is degraded with concentric intensity. Annual forage productivity can be halved in just a few years. Moreover the reduction of the tree supply also has a detrimental effect on the seasonal forage availability; effectively, the leaves of trees and shrubs remain green for longer than the grass and consequently represent an unalterable source of forage for the arid periods. The seasonal forage shortage in turn causes a higher and excessive intake of the remnant vegetation, especially of the seeds that are often the only available food during the dry season. Seed removal has dramatic and negative effects on the sustainability of production.

Figure 1. Rangeland peoples fell trees or collect branches for fuel and timber. This is particularly dangerous when the productivity of the vegetation is low as a result of climatic limitations.
(Source of photo: A. Pardini, *unpublished.*)

2.2. Effects on Biodiversity

The decrease in productivity normally becomes clear in the short term, while changes in botanical composition are slow to become detectable; nevertheless one type of degradation is normally intrinsically bound up with the other. Biodiversity becomes reduced over a lifetime, and the length of this period is sufficient to allow adaptation in the human sense. The small daily changes are not perceived as a dangerous trend, whereas unfortunately they can, in the long term, reduce the resilience of the ecosystem

to environmental changes, trigger the start of the desertification process, and reduce the possibility of developing more differentiated economies.

The progress of degradation is exacerbated by both the change in land use and the increase in international commerce and transportation. Obstacles to the movement of organisms have been both removed and created, and reduced biodiversity is often accompanied by the diffusion of a few cosmopolitan species that spread all over large areas and take over from the native species. The arrival of invasive species has altered the fire and nutrient cycling of the ecosystems. Annual species were favored by intensive and irrational agriculture and pastoralism, and their spread led to the biological pollution of extensive areas. Some of the exotic species have succeeded in being positively integrated in the colonized areas; others, instead, have produced negative effects after only one century.

Current developments brought about by computer monitoring and by the increased diffusion of mechanization make it extremely likely that this type of change will be even more marked in the future.

3. Management Solutions

There are numerous reasons behind the degradation of the rangelands in many parts of the world. Normally direct human intervention is the principal cause of degradation, which is then further exacerbated by the excessive number of livestock (Table 1).

	Cause	Effect
(a)	Wood collection and tree cutting	Reduced vegetation cover; decreased seasonal availability of forage; deterioration in microclimate, also for herbaceous pasture
(b)	Excessive stocking rate	Excessive intake; reduction of vegetation cover; diffusion of unpalatable and toxic-poisonous species; reduction of the seed bank in the soil
(c)	Absence of rotation of the grazing sectors	Continuous removal of tissues and nutrients from the plants; management difficulties (weed mowing, manure distribution)
(d)	Excessive frequency of pastoral fires	Extinction of or damage to the perennial species, destruction of annuals, destruction of unburied seeds; nutrient leaching; soil erosion
(e)	Lack of improvements to sustain productivity and biodiversity (sowing, fertilization, weed control)	Vegetation productivity lower than optimal; reduced soil fertility; invasion of alien species
(f)	Use of unsuitable animal breeds or nonselected genotypes	Animal productivity lower than optimal (temperate breeds introduced in the tropics); low meat transformation rate (native animals not bred)

(g)	Absence of handling facilities	Damage to the soil by trampling; reduced animal productivity; diffusion of animal disease; increased number of animal deaths
(h)	Lack of differentiation of the vegetation resources	Sensitivity to seasonal and annual variations of climate; diffusion of phytopathologies; excessive specialization of produce

Table 1. Causes of degradation due to bad management and the negative effects on the rangeland

Solutions commonly proposed to cause of degradation include the following:

(a) *Control of wood collection and tree felling*. Rules already exist in many countries, but these are often largely ignored because of the absence of other resources. Results have been positive only where alternative building materials and energy sources were made available to the population. Sometimes there has been a strategy of replanting trees in the pastures or around the edges to form windbreaks or green fencing; unfortunately this is not very common.

(b) *Balanced animal-stocking rate*. Where the lifestyle of the populations is still based on traditional models there is resistance to a reduction in the number of livestock, because the social importance of the person or family is derived from the number of animals owned. Usually such traditions survive in areas subject to long droughts where the animals survive longer than the crops, thus guaranteeing a source of food. In these cases, food security must be achieved before a consistent reduction of the livestock can be planned. In the more developed economies, animal-stocking rates are usually maintained near an optimal level in the long term; nevertheless, calculation methods based only on biomass weighing or mathematical or photographic models should be substituted by more precise methods that comprise biomass weighing and analysis of the botanical composition.

(c) *Grazing sectors*. The rotation of the animals allows a higher intake rate and less selection of the species. The spread of unpalatable weeds is obstructed by the temporary high stocking rate; moreover, the remaining weeds can be killed after the animals have been moved to another sector. Pasture sectors can be separated by (green) fencing that can also include windbreaks, which means that green leaves will also be available during the dry season.

(d) *Control of pastoral fires*. Fires are seasonally set by shepherds to stimulate new sprouting after the dry period. While fire occurs naturally, and has a strategic importance in the maintenance of the productivity of certain ecosystems, it can produce negative effects when too frequent or when large biomasses are involved. Excessive frequency reduces the seed bank in the soil, and large and tall biomasses involve the risk of the flames spreading to trees; fire can also cause the fluidification of nutrients, which become condensed in a film a few centimeters beneath the surface of the soil when temperatures of about 1000 °C are reached, and this in turn favors soil erosion by water.

(e) *Improvements on the vegetation and the soil*. Sowing–oversowing of good forage species should be predominantly based on legumes; nevertheless, preference should always be given to native species and local ecotypes. Thus, breeding programs are necessary. Mineral fertilization has an immediately positive effect on the production; however, the prolonged application of mineral fertilizers changes the balance of the nutrients in the soil and has been proved to reduce biodiversity. Weeds are normally controlled by periodic fires, mechanical intervention, and herbicide spraying. All these methods have strong positive and negative effects, and their use should be limited. Human mowing or short periods of grazing with very high stocking rates have a minor impact on the ecosystems and should be preferred in marginal areas and those where technical controls are difficult.

(f) *Animal breeds and nonselected genotypes*. The introduction of animal breeds adapted to warm climates and rough pastures, such as those selected in the Mediterranean basin, could enhance the survival of the selected breeds more commonly used and increase the rate of meat production of the native genotypes. This option is rarely pursued due to lack of knowledge about the available breeds.

(g) *Handling facilities*. These normally allow an increase in the number of livestock and also reduce the negative impact on the resources. Water stores reduce the number of deaths in arid climates and contribute to a reduction in the number of animals that the population must own to achieve food security. Watering facilities distributed throughout the territory avoid the necessity for long daily walks and the risk of trampling, especially in the areas near the watering points. Fences and grids help to contain the daily movements of the animals. Disinfectant baths at the entrance to each sector reduce the incidence of disease and contribute to the reduction of the number of livestock that must be maintained.

(h) *Increased diversity of the vegetation*. Greater biodiversity within the pasture (botanical composition comprising more then 20–30 species, trees included) contributes to the regularization of the seasonal availability of forage and to a reduced sensitivity to the negative effects of the deteriorating annual trends of the climate. Greater diversity in the use of the soil (forest areas as well as pastures) enhances the resilience of the area to negative trends and favors the diversification of the local produce.

The adoption of the solutions proposed can optimize the number of livestock; however, there is a limit to their efficacy related to the natural productivity of the ecosystem. When this limit is reached, no further improvements are possible unless new scientific advances and new technologies are available. Once the limit of the productivity is reached, part of the population has to move to another area, even if optimal management is applied. An alternative solution is to remove building materials, energy, and food from the system, though is possible only if part of the population can rely on resources other than those of the rangeland. In this final stage, the economic diversification of the whole economy of the area or country is necessary.

3.1. The Utility of Resource Diversification

The diversification of the entire economy is favored when the resources of the territory are also diversified, so that these two aspects ought to be integrated. Unfortunately, often this is not the case: in the developing countries scant availability of technologies results in the suboptimal utilization of the territory, while in the developed areas capital is used to maximize profits regardless of the possible damage to the ecosystems.

A good level of resource diversification exists in some Mediterranean European areas; this is due both to geographic heterogeneity and a diversification of the economy through which the majority of the population is employed in extra-productive activities. Recently, large areas of land have been transformed from agricultural and pastoral activities to extra-productive uses. Nevertheless, the positive effects of such diversification failed where the natural resources have been excessively fragmented and have reduced the ecological efficiency. Complexity of management and reduced incomes are part of the diversification, and yet over the last 2000 years this geographical area never suffered a crisis of the ecosystems comparable to that experienced in the modern crop systems, based on very limited diversity, which became unstable over a single century. This comparison confirms that the opportunistic simplification of the resources can maximize profits in the short term, but could lead to severe crisis in the long term. Sustainability is intrinsically linked to the maintenance of elevated biodiversity; this is a concept that will be of increasing importance in the future if climate modifications come to exacerbate the instability of production.

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Biographical Sketch

A. Pardini: Born in Florence, Italy, on July 25, 1959. 1985: University degree (five years) in Forestry Sciences from the University of Florence. 1992: Doctorate on "Mountain pastoralism and forage crops" from the University of Florence. 1992: Researcher at the University of Florence, Department of Agronomy and Land Management. Since 1995: Scientific director in Florence of a project within the Advanced Researches in Agricultural Systems Innovations (RAISA) national program of the National Research Council. 1995: member of the Italian Agronomy Society (SIA). Since 1996: Team leader on the project: "Mediterranean Grazing Systems" coordinated by the European and Interregional Co-operative Network of the Food and Agricultural Organisation of the UN on "grazing systems". 1998: Associate professor of rangeland management at the University of Florence. Member of the Australian Rangeland Society since 2000.

Experience of research carried out in Australia, Bolivia, France, Greece, Kenya, Madagascar, Oman, Peru, São Tomé and Principe, Somalia, Spain, and Tanzania.