**CHAPTER 1. INTRODUCTION**

* 1. **Rangeland definition, Importance, and Utilization Systems**

Objective of the chapter

* After the end of this chapter students will be able to:-
	+ Define rangeland and related terminologies
	+ Explain the importance of rangelands
	+ Identify the goods and services obtained from rangelands
	+ Describe basic principles of range management systems

**Rangelands** are areas of the world, which by reasons of physical limitation, low and irregularprecipitation, uneven topography, poor drainage, or cold temperatures that are unsuited for farming and important source of forage for free ranging native and domestic animals, as well as a source of wood products, water & wildlife (Herlocker, 1999).

**Rangelands** are also lands that are not: farmed, dense forest, entirely barren, or covered with solid rock, concrete, or ice. Range lands are ecosystems which carry vegetation consisting of native or naturalized species of grasses and herbs, trees, & shrubs used for grazing and browsing by wild and domestic animals.

**Range:** is a relatively extensive area of land suitable for grazing but not for cultivation,especially in arid, semi-arid or forested regions. Range embraces *rangelands* and also many *forest lands* which support an understory or periodic cover of herbaceous or shrubby vegetationamenable to certain range management principles or practices.

**Ecology is** the study of **interactions (relationships)** between and among the organism(s) and theenvironmental factors, which determines the organism(s) distributions, abundance, rates of productivity and evolution.

**Ecosystem**: is a ―functional unit consisting of organisms (including man) and environmentalvariables of a specific area‖. Ecosystem contains living (primary producers, consumers, and decomposers) and non-living elements (climate, soil, topography, water, air, sun, and…….). It is an area with similar ecological characteristics on which man has placed boundaries for management purposes. There is an exchange of energy and matter among these components.



**Forage’** is the vegetative plant parts (flowers, leaves, stems & roots) eaten by animals.

**Browse**: leaf and twig growth of shrubs, trees, cacti, and other non-herbaceous vegetation available for animal consumption.

**Herbage**: the biomass of herbaceous plant, other than separated grain, generally above ground but including edible roots & tubers.

**Litter**; An accumulation of dead detached plant material at the soil surface

**Defoliation** - Removal of plant tissue by grazing animals or machinery.

**Graze**: To consume predominantly herbaceous forage **by animals**

**Paddock**-grazing area that is a sub-division of a grazing management unit and is enclosed and separated from other areas by a fence/barrier

***Rangeland Ecology*** is the science of the relationships between rangeland plants, animals and their environment.

**Range management**: is themanipulationof rangeland components toobtain the optimum combination of goods and services for society on a sustainable basis. It has two components:

1. Protection and enhancement of the soil/vegetation complex
2. Maintaining or improving the output of consumable range products, such as meat, etc.

|  |  |  |
| --- | --- | --- |
| **Services** |  |  |
| 1. | Climatic stability | 6. | Organic matter decomposition |
| 2. | Water and air purification | 7. | Ozone maintenance |
| 3. | Nutrient cycling | 8. | Pest and disease control |
| 4. | Biodiversity | 9. | Aesthetic value |
| 5. | Human waste decomposition and | 10. | Outdoor recreation |
|  | Detoxification |  |  |

**Products**

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | source of feed for Animals |  | Energy (fossil fuels, bio-fuels, hydro, |
| 2. | Water |  | solar, wind and thermal power) |
| 3. | Food (meat, fruit, vegetables, nuts) | 6. | Minerals (gold, iron, silver, lead) |
| 4. | Fiber (leather, wool) | 7. | Wildlife |
| 5. | Medicine (Produces medicinal | 8. | Fish |
|  | plants) | 9. | Timber, pulp and paper |

**Major Uses of Rangeland Resources**

* Source of forage for wild and domestic animals
* Source of livestock production (meat, milk…)
* Sources of mineral
* Water management: Proper rangeland management results in healthy ecosystems which enhance the quality of water and
* Minimize soil erosion and sedimentation.
* A habitat for a wide array of wild life species and for diverse and wide range of native plant and animal species.
* Aesthetic value: rangelands possess natural beauty & other aesthetic values.
* For medicinal plants and wood products
* Recreational and tourism,
* The rangeland soils & vegetation are large stores of soil carbon and used as a carbon sink.
* Sources of biomass for fuel, building materials, Industrial products

**Basic Principles of Range Management**

When managing a pasture both the plant and the animal need to be considered. If the pasture is grazed too hard both plant and animal production will be reduced. If the grazing pressure is too light forage use will be low, forage quality may decrease and animal production per acre will be low.

**Principles related to animal practices (grazing mg’t)**

Grazing management refers to the manipulation of grazing animals to achieve desired results. Management of grazing results in maintenance or improvement of range productivity, efficient utilization of the forage resource, production of animal products from livestock and/or wildlife.

Grazing pressure can be manipulated either by changing the number of animals per unit grazing area or by lengthening or shortening the time the animals spend on the pasture.

**A. Regulating the stocking rate**

This refers to restricting the number of animals that can be grazed in a given area. Hence, proper stocking involves obtaining the proper ratio between animal numbers and grazable forage such that the animal can meet its intake requirements and the plants can meet their requirements for growth and reproduction. The amount of grazable forage present on the range is the primary component determining the stocking rate.

**B. Proper distribution of grazing**

Animals never graze vegetation uniformly. They are area selective and species selective grazing. Area selective grazing results from the preferences of animals for grazing in certain areas as opposed to others. Many factors cause area selective grazing.

* Size and shape of pastures
* Soil factors (fertility, texture, etc.)
* Location of water, salt
* Prevailing Topographywinds & other environmental factors
1. **Principles related to range vegetation**
2. Elimination or suppression of undesirable plant species by proper grazing management and bush control,
3. Seeding improved forage species to supplement those existing in the natural vegetation.
4. Fertilizing to correct soil deficiencies.
5. Soil conserving practices to control water erosion.

**1.2.1. Range Management and its Relation to Other Sciences**

Range management, as a profession is unique among others in that it deals with the animal-plant interface rather than with plants or animals in neither isolation nor the biotic without the biotic components. Range management unlike other disciplines is related with other disciplines that have relevance to the rangeland. Range management integrates in to unified system knowledge (scientific knowledge).

Range management, whether as a practice or as a science, is intimately associated with other more or less closely allied disciplines that contribute to range management these disciplines include: **Animal science**, (wild life science, livestock management, animal nutrition, animal ecology, animal breeding and behavior etc.), **Plant science**, (plant physiology, plant ecology, ecophysiology, plant taxonomy, forestry etc.), **Social sciences** (economics, anthropology, labor management, etc) and **Abiotic sciences** (climatology, hydrology, soils, remote sensing, mineralogy etc.). The basic components of range management can be categorized in **to** **biological** and **physical.**

At the beginning range managers were concerned primarily with the **biological components**, particularly plants, (responses of plant communities to grazing which intern knowledge of plant physiological processes). There is also a need to understand the **physical environmental** factors as these affects plant productivity.

Different animal species affect rangeland ecosystems in different ways, and animal productivity is not constant among rangeland ecosystems. Here a range manager has a thorough understanding of the behavior and nutritional requirements of domestic and wild animals if their productivity is to be maximized.

An understanding of social, economic, cultural, and technological considerations is a critical part of the range management profession as the objective is also production (not only protection) of products used by human kind. As an example, the need of the west is recreational pursuits while in developing countries range management needs to serve the population in getting its daily requirements. Hence the role of range management in developing countries needs re-designing and re-defining. In the past the focus of range management has been on cash income generation from a single product-beef. This has persuaded many African governments to convert the predominantly subsistence pastoral economy to cash generation through ranching, grazing blocks, grazing cooperatives etc.

**1.4. Rangeland Degradation and the Role of Range Management**

**Degradation** means a decrease in plant species diversity, plant height, vegetation cover andplant productivity. Recently, degradation has also come to mean deterioration in ecosystem services and functions, such as decreased water and soil conservation, recreation values, carbon balance and so on. Rangeland degradation implies a reduction in rank or status, which includes a loss of top-soil, a change to a simple floral/ fauna composition or a transition from one organic form to a lower organic form, and continuous reduction of productivity/biomass of the ecosystem.

**Causes of rangeland degradation include:**

* **Climatic changes-** largely severe and prolonged drought which causes gradual replacementof the more palatable grasses by undesirable species.
* **Overgrazing**- due to overstocking and probably the most acute problem of rangemanagement.
* **Uncontrolled fire**
	+ Increased danger of erosion;
	+ Destruction of micro-organisms near the soil surface
	+ Loss of nutrients; and
	+ Removal of plant biomass,
* **Cultivation**- destruction of range vegetation by agriculturists who then abandon the landbecause climatic conditions do not favor arable farming.
* **Communal grazing-a** factor in regions where no restrictions are placed on cattle numbersand owners or keepers have no responsibility for range management.
* **Socio-economic** - applied to societies where cattle herding are a symbol of wealth andprestige.
* **Rodents and predators** - an underestimated but prevalent damage by rabbits, hares,kangaroos, rats and other small rodents which **consume forage.**
* **Invasive species, human activities**, and removal of plant biomass, plant responses are someof the rangeland change factors.

**Table 1. Biophysical indicators of rangeland degradation**

|  |  |
| --- | --- |
| Attributes | Symptoms |
|  |  |
| Soil | Decreased fertility |
|  | Decreased water holding capacity |
|  | Decreased infiltration |
|  | Decreased top soil depth |
|  | High rates of erosion |
|  |  |
| Vegetation | Changes in productivity over time unrelated to rainfall pattern |
|  | Changes in cover |
|  | Changes in species composition of use to animals |
|  | Shifts between vegetation states to a low fodder value (e.g. palatable to |
|  | invader species) |
|  |  |

**CHAPTER. 2 CLASSIFICATION OF RANGELAND**

Objective of the chapter

* After the end of this chapter students will be able to:-
	+ - Define classification
		- Classify rangelands based on their vegetation
		- Classify rangelands based on their ecology
		- Describe basic features of each rangeland type

**Classification**: is identification and grouping of individuals on the basis of specified attributes(soil type, vegetation type, etc.). The end result should be a set of groups, where every individual within a group is more similar to other individuals in that group than to any individual in any other group. Rangeland can be classified in several ways.

The requirements for classification are:

* To assist in the management of land already under economic production
* To indicate priorities in the development of new areas

Based on vegetation type, the major rangeland types of the world are **grasslands, desert** **shrub lands, savanna woodlands, forests, and tundra.** These are the basic rangeland types ofthe world. The type of rangeland must be considered when planning management activities because they differ in precipitation, soils, and terrain. Therefore, management practices that work well in one region may be unsuitable for another region.

**A. Grasslands**

Grasslands are generally dominated by plants in the family Gramineae and are virtually free of woody plants. They are the most productive rangelands in the world for providing forage for wild and domestic ungulates. Grasslands generally occur in areas receiving between 250 and 900 annual precipitation. This precipitation most often occurs as frequent light rains over 90 days or more, with the bulk of the moisture falling in the summer months. These conditions favor grasses, whose fibrous roots can effectively gather moisture from the soil surface. The soils of grasslands are more than 2 meters (m) deep, loamy textured, high in organic matter, and very fertile.

Throughout the world, grasslands go by many names including **prairie, steppe, pampas,** **swards, meadows and velds**. In North America, grassland biomes include the tall grass prairie,short grass prairie, alpine meadows, California annual grasslands, Palouse prairie, southern mixed prairie, marshes, wet meadows, tundra grasslands, and desert grasslands

**B. Desert Shrub lands**

Desert shrub lands are the driest of the world‘s rangelands, usually receiving less than 250 mm of annual precipitation (Receive <250 mm of annual RF.). Include woody plants <3m height with a sparse herbaceous understory. Received the greatest degradation by heavy grazing and show the slowest recovery. The precipitation in desert shrublands varies greatly from year to year, occurring as infrequent, high-intensity rains in less than 90 days. As a result, the water content of the soil surface is very dry for much of the year and out of reach of the short fibrous roots of grass plants. These conditions favor shrubs whose long tap roots can collect moisture from deeper within the soil profile. Desert shrubs are typically spaced farther apart, allowing their roots to spread laterally and collect water over a large area. Soils of desert shrublands are typically sandy to loamy textured and vary in depth. The amount of herbaceous understory depends on the texture of the soil and how quickly water percolates into deeper soil profiles.

Shrub lands across the world are called chaparral, cerrados, shrub‐steppe, maquis, and scrublands. In North America, shrub land biomes include chaparral, sagebrush‐steppe, salt‐desert shrublands, tundra shrublands, and mountain browse.

**C. Savanna Woodlands**

Savanna woodlands have a productive herbaceous understory dominated by scattered, low-growing trees, less than 12 m tall. However, when there is heavy grazing usually results in loss of understory grasses and an increase in the density of the trees and shrubs. Savanna woodlands occur as a transition zone between grassland and forest. Shifts to grassland or forest depend on grazing intensity, fire control, logging, and draught. E.g. Fire and heavy grazing of the understory increases the density of shrubs and trees.

**Woodlands** and **Savannas** are dominated by widely‐spaced trees including junipers, oaks,mesquite and pines with an understory of grasses and forbs. Wood land ecosystems across the world take the names of the trees that dominate the landscape. In North America, the largest wood land biome is the pinyon‐juniper woodland. Other woodland and savanna ecosystems include oak woodlands, aspen savannas, and mesquite woodlands.

**D. Forest**

Forest differs from savanna woodlands by having long trees over 12m height and closely spaced. The closely spaced; taller trees of forests prevent the development of a herbaceous understory with any grazing value. Forests generally occur in high-rainfall areas (more than 500 mm) because of the greater amount of moisture needed to support the biomass of a forest. The coarse-textured and/or thin, rocky soils favor forest over grassland because they retain low amounts of moisture near the soil surface but store considerable moisture deep in the soil profile and/or rocky crevices. High precipitation causes substantial leaching of soil nutrients; therefore, forest soils are generally low in fertility. Thinning forests through logging or fire can open the canopy and create areas of valuable forage to wildlife and livestock. Mainly, forests are managed primarily for timber production and are too dense to have any grazing value.

**E. Tundra**

Tundra is a level and treeless plain in arctic or high-elevation regions that cover about 5% of the earth‘s surface. The extremely cold climate keeps tundra frozen for more than seven months of the year, and the permafrost restricts tree growth. Arctic tundra occurs over large areas in North America, Greenland, northern Europe, and northern Asia. Vegetation on the tundra consists primarily of low-growing, tufted perennial plants and lichens. The main types of woody plants are shrubs of the genus Salix. Low precipitation (250 mm to 500 mm) and strong winds make the tundra an inhospitable place for most plant life. Tundra is rarely used for livestock grazing because of its rough terrain and short grazing season (less than 90 days). However, Peru is an exception, where the alpine tundra is used extensively by alpacas and llamas.

**2.1. Ecological Classification**

**Moisture availability** is one criteria of ecological classification. Based on **moisture, East African Range lands** were classified into 7 zones (Thorn- thwaite and Penman).

1. **Afro-alpine climate**
* Afro-alpine moorland and grassland, or barren land at high altitude above forest line
* Limited use and potential except as water catchment and for tourism
1. **Humid to dry Sub-humid.**
	* + - Dry forests and derived grasslands and evergreen bush lands
			- The potential is for forestry, wildlife and tourism, agriculture
2. **Dry sub-humid to semi-arid**
	* + Moist woodland, bush land or savanna
		+ Land not forest potential
3. **Semi-arid**
	* Land of marginal agricultural potential
	* Dry forms of woodland and savanna
	1. **Arid**
* Dominated mainly by *Commiphora, Acacia,* and allied genera, mostly of shrubby habit
* May be suited to agriculture only when fertile soil coincides with very favorable distribution of rainfall or run-on
	1. **Very arid**
	+ Rangeland of low potential
	+ The vegetation being dwarf shrub grassland or shrub grassland
	+ Population of both wild and domestic animals are restricted severely by the environment
1. **Desert**

**2.2. Physiognomic Classification**

This is based on **vegetation types** (manly on the contribution of woody and grass species). The vegetation types presented here is basically that recommended by the East African Range Classification Committee (Pratt and Gwynne, 1977):

1. **Forest (F)**: Land covered by a closed stand of trees of one or more story, rising to 7-40m ormore in height; the ground cover is dominated by herbs and shrubs
2. **Bushland (B)**: Land supporting an assemblage of trees and shrubs, often dominated byplants of shrubby habit but with trees always conspicuous, with a single or layered canopy, usually not exceeding 10m in height; total canopy cover > 20%
3. **Woodland (W)**: Land supporting a stand of trees, up to 20m in height, with an open orcontinuous but not thick; canopy cover > 20%; shrubs, if present, contributes less than one tenth of the canopy cover; grasses and other herbs dominate the ground cover.
4. **Shrubland (S)**: Land supporting a stand of shrubs, usually not exceeding 6m in height;canopy cover >20%; trees, if present, contributes less than one tenth of the canopy cover; ground cover is often poor.
5. **Grassland (G)**: Land dominated by grasses and occasionally by other herbs, sometimeswith widely scattered or grouped trees and shrubs; the canopy cover does not exceed 2%; usually subjected to periodic burning.
6. **Bush Grassland (BG)**: Grassland with scattered or grouped trees and shrubs, notnecessarily equally represented but both always conspicuous and with a combined cover of less than 20%; may be subject to periodic burning.
7. **Wooded grassland (WG)**: Grassland with scattered or grouped trees, the trees arealways conspicuous, but having a canopy cover less than 20%; often subject to periodic burning.
8. **Shrub Grassland (SG)**: Grassland with scattered or grouped shrubs, the shrubs alwaysconspicuous, but having a canopy cover of less than 20%, may be subject to periodic burning.
9. **Dwarf Shrub Grassland (dSG)**: Grassland, often sparse grassland set with dwarf shrubsnot exceeding 70cm in height, sometimes with widely scattered larger shrubs or stunted trees; burning is rare.
10. **Permanent Swamps (PS)**: Land covered by permanent standing water and supportingvarious plant communities, including sedges, sometimes trees or shrubs, and aquatic species.

**k) Baren land (b)**: land naturallydevoid ofvascular plants.

**Rangeland types of Ethiopia**

The Ethiopian rangelands or lowlands are home to 12% of the human population and 26% of the livestock population. The lowlands occur below 1500 m elevation and comprise 61% of the national land area. Climate in the lowlands includes arid (64%), semi-arid (21%) and sub-humid (15%) zones largely defined by four temperature and RF regimes. The regional variation in temperature and rainfall in the lowlands provides a basis for understanding climatic variability. So, the rangeland of Ethiopia is classified into three agro-ecological zones.

**1. Arid zone (64%)**

* + Has up to 90 growing days per year
	+ This zone is the warmest areas such as Dalul in Afar, Issa in Somali, Ogaden, etc.
	+ Receive RF <400mm/year.
	+ Vegetation types include dwarf shrub grassland and dry thorn bush land.
	+ Range plant communities have low production potentials
	+ Human lifestyles are nomadic, involving frequent movements of households and animals.
1. **Semi-arid zone (21%)**
	* This zone has from 90 to 180 growing days per year.
	* The altitude ranges below 1500m.a.s.l.
	* The Borena, Nuer, most of the Afar region, some of the Somali region.
	* Receives RF 400-700 mm/year.
	* Range plant communities have much higher potentials than the arid zone.
	* Plant communities commonly consist of perennial savanna and dry woodlands with grasses.
	* Promotes more grazing cattle and sheep, although browsing goats and camels can thrive in wooded and bushed areas.
	* People tend to be semi-nomadic, with households sedentary in most years and livestock being mobile if necessary.
	* Agro-Pastoralism may also emerge on favorable water collecting landscapes and maize/sorghum is an important food staple.
2. **Sub-humid zone (15%)**
	* This zone has 180-270growing days/year.
	* Occurs near 1500m elevation.
	* Has annual RF (800-1300mm) and lower temperature.
	* Native vegetation types commonly consist of moist perennial savannas and woodlands.
	* Sedentary mixed crop-livestock operations are more the norm.
	* Common livestock are cattle, sheep and goats. Camels are few in number.

In general, Pastoral communities living in the Ethiopian rangelands constitute roughly 10-12% of

the Ethiopian population inhabiting some 60% of the country‘s land mass mainly the peripheral areas of the country (Hogg, 1997; Melaku, 2000). The main pastoral communities are the Somali

(53%), Afar (29%) and Borena (10%) living in the Southeast, Northeastern and Southern parts of

Ethiopia respectively and the balance (8%) are found in Southern, Gambella and Benshangul regions (Sandford and Habtu, 2000). The majority of these are pastoralists engaged in extensive livestock herding. Within and between each of these groups there are different adaptive specializations dependent on varying ecological, economic and cultural factors.

**CHAPTER 3. PRINCIPLES AND DESIGNS OF GRAZING SYSTEMS**

Objective of the chapter

* After the end of this chapter students will be able to:-
	+ - Define grazing
		- Define grazing terminologies
		- Identify and explain grazing systems
		- Describe the advantage and disadvantage of each grazing system

**Grazing** is the harvesting of herbage by herbivores and it is an efficient method of herbageutilization between the animals are self-propelled, they move to the feed and provide their own cutting equipment.

**3.1. Grazing Terminology**

**Grazing management** is the manipulation of animals to accomplish desired result in terms ofanimal, plant, land, or economic responses.

Deferment, rest, and ration are terms that receive constant use when grazing systems are discusses

**Deferment**: - involves delay of grazing in a pasture until the seed maturity of the **key forage species**.

This permits the better forage plant to gain vigor and reproduce.

**Rest**: - it is distinguished from deferment in that the range receives non-use for a full year rather than justduring the growth periods. This gives plants a longer period to recover from past grazing influences and provides wildlife with a pasture free from livestock use during the critical dormant period.

**Rotation:** it involves the movement of livestock from one pasture to another on schedules basis. Themain advantage of rotation is that key forage plants are provided with periodic non-use during the critical growing season. Systems with deferment and rest typically involve livestock rotation.

**Grazing Terminology**

**Grazing season**- this refers to the time during a year when grazing is feasible and can be accomplished without damage on the vegetation of an area. In other words it is part of the year where there is possibility to graze the rangeland without causing severe damage on the vegetation

**Grazing period**- this is the length of part of the grazing season with in which grazing actually occurs. It is the length of time that grazing livestock or wild life occupies a specific land area

**Grazing event**- is the length of time that an animal grazes without interruption.

**Grazing cycle**- the time elapsed between the beginning of one grazing period and the beginning of the next grazing period.

**Repeated seasonal grazing**- this involves grazing a range unit at the same time each year. **Deferment or defer grazing-** thisrefers to the avoidance ofgrazing until plant reproduction is complete, Establishment of new plants, or restoration of plant vigor.

Deferment permits gain in plant vigor, increased seed production, and improves range health.

**Rest**- this refers to the total absence of grazing for a full growing season and is larger than the deferment. Unlike the deferred grazing, the rested portion is not grazing at all.

**Grazing area**- refers to the unfenced divisions, which are grazed according to the marks of the herders.

**Grazing cell**- refers to land managed as a unit for grazing.

**Paddock**- refers to fenced divisions of a grazing cell.

**Continuous stocking-** this is a method of grazing livestock on a specific unit of land where animals have unrestricted and uninterrupted access throughout the time period when grazing is allowed.

**Creep grazing**- this refers to the practice of permitting juvenile animals to graze areas that their dams cannot access at the same time.

**Grazing management**- this refers to the manipulation of animal grazing in pursuit of a defined objective.

**Grazing land management**- this is the manipulation of the soil- plant- animal complex of the grazing land in pursuit of a desired objective.

**Grazing system**- is a defined, integrated combination of animal, plant, soil, and other components and the grazing method(s) by which the system is managed to achieve specific results or goods.

**3.2. Grazing Systems**

There are different systems of grazing. How animals are managed on pastures can have strong effects on forage production and persistence, as well as on animal production. Selection of grazing management practices is a key decision in designing a pasture management program. Some important grazing practices are listed below

**A. Continuous grazing**

In this system of grazing the animals are placed on the range and allowed to remain year long or throughout the grazing season. Animals have unrestricted and uninterrupted access throughout the time period when grazing is allowed. Continuous system of grazing has been blamed by many for its undesirable effects on species composition of the vegetation. This is due to the fact that livestock have preferred areas (sacrifice areas) for grazing, the location of which is where there is water, highly palatable forage species, ground salt licks, and shade in close proximity such areas are the most productive part of the pasture. These are areas that attract animals and lead to over use of part of the range.

Advantages of continuous grazing:

* + There will not be unused forage at the end of the calendar
	+ Requires less management
	+ Because animals have free access, they can select the most nutritious species before losing their grazing value.
	+ It requires minimal cost for fences

Disadvantages of continuous grazing:

* + Lower forage quality and yields
	+ Uneven pasture use
	+ Greater forage loss due to trampling
	+ Animal manure distributed unevenly
	+ Weeds and other undesirable plants may be a problem

**B. Rotational grazing**

The pasture area is divided into two or more sub pastures, also called ―paddocks, ‖ with each sub pasture being grazed and ―rested‖ in turn. When a paddock is grazed off, animals are moved to a fresh one, allowing each paddock to be grazed clean and to have a rest period. The rest period is critical for the continued productivity of some forage species. Time that animals are on a paddock is referred to as the grazing period; time off the paddock is the rest period. Number of animal is maintained according to carrying capacity of grassland. Well-managed grassland can sustain stocking rate of 5 animals/hectare. Normally 1 hectare is allowed for 100 animals for each day grazing. The recovery period between grazing depends up on the agro-ecological situation and grass species. An interval of 3 or 4 week is usually adopted successfully. The change over from one compartment to another provides the advantage of giving animal young, palatable and nutritive herbage and provides a period of rest to grasses during growing season which results in good regeneration by vegetative means. Allow grazing to begin when tall grasses reach 7 to 8 inches, and remove animals when grass heights fall below 3 inches. Begin grazing short grasses such as Kentucky bluegrass or perennial ryegrass when they reach 5 to 6 inches; remove animals when grass heights are 1 to 2 inches. To maintain milk production levels, you may need to remove highly productive dairy animals from paddocks before the plants reach these heights. Rotational grazing systems vary in design and intensity.

Advantages of rotational grazing

* Highest forage production and use per acre
* More even distribution of manure throughout the paddocks
* Weeds and bush are usually controlled by grazing
* Provides more grazing options
* Reduces mechanically harvested forages

Disadvantages of rotational grazing

* Requires careful monitoring
* Initial cost may be higher due to fencing materials and water distribution systems
* Requires more management

**I. Deferred – Rotation**

**Deferment** involves delay of grazing until seed maturity of the important forage species iscompleted. **Rotation** is the movement of livestock from one pasture to another on a scheduled basis. In a deferred system grazing is delayed for a prescribed period, usually from initiation of new growth until seed maturity.

**ii. Rest-Rotation**

In a rest-rotation system each pasture unit is rested for a certain period during a year while other units are grazing. Mostly a unit is rested for a full year in each rotation sequence which may be 3 -5 years or more depending on the number of pasture units and expected grazing period during the grazing season. In addition to the year‘s rest, grazing is periodically deferred in each pasture until seed ripening of key species.

**C. Deferred grazing**

This system of grazing consists of subdividing grassland into three compartments with grazing allowed alternately in two and third completely closed during the growing season until seed maturity. This gives grasses a change to make sufficient growth and accumulate sufficient reserve food material to maintain the vigor of plants and regenerate form the seed that are shed. Grazing is deferred in different compartments each year. This way each compartment gets adequate period of rest and chance for recovery.

**D. “Creep” Grazing**

Excluding mature animals while allowing young calves and lambs access to high-quality, highly palatable forage is known as creep grazing. This can be achieved by raising the electric fence high enough to allow young animals to walk under but low enough to restrict the movements of larger, more mature animals. A special creep gate also can be used to allow the young animals to graze the ―creep‖ pasture and to return for suckling, much like a creep **grain feeder**. In rotational grazing systems, the ―creep‖ gate can allow young animals to graze the next fresh paddock before mature cows or ewes.

**E. Mixed Grazing**

Grazing of pastures by two or more species of animals (beef and sheep, sheep and goats, etc.) has advantages. Animal species differ in the types of forage they prefer. Beef cattle prefer legumes over grasses, while sheep prefer immature grasses and weeds over legumes. Goats consume shrubby vegetation, in addition to forage plants.

Sheep, goats, and cattle tend to be complementary in their grazing habits; thus, two or more animal species together can better utilize the forage. Goats also help control weedy vegetation. Co-grazing does not increase the overall animal-equivalent carrying capacity of a pasture.

**CHAPTER 4. STOCKING RATE AND CARRYING CAPACITY AS MANAGEMENT TOOLS**

**Objective of this chapter**

* **A**fter the end of this chapter students will be able to:-
	+ - Define stocking rate and carrying capacity
		- Explain potential effects of high and low stocking
		- Calculate forage demand of animals
		- Calculate forage production
		- Calculate stocking rate
		- Identify factors consider when stocking rate calculation is planned

**4.1. Definitions and classification**

**Stocking rate** is the actual number of animals or animal unit on a specific area for a specificperiod of time usually for grazing season. It is also defined as the number of animals grazing a unit area usually 1 hectare at a particular time.

**Carrying capacity:-**The following are different definitions of carrying capacity. The number ofanimals that can graze in a unit area without over or under grazing in an average season is referred to as **carrying capacity of the grassland**. Carrying capacity is the *maximum possible* *stocking rate of herbivores* that a *rangeland can support on a sustainable basis*.‖Carryingcapacity is the maximum stocking rate that will achieve a target level of animal performance, in a specified grazing method, that can be applied over a defined time period *without deterioration* *of the ecosystem*.

The use of the concept of cc from commercial and ecological sense has lead to two types of carrying capacities referred to as ecological and economic carrying capacities.

**A) Ecological Carrying Capacity**

This refers to the *maximum number of animals the land can hold without being subject to density dependent mortality and permanent environmental degradation.*

This is the point at which livestock populations cease to grow because limited feed supplies result in death rates similar to birth rates. The rate of production of edible forage equals the rate at which the edible forage is consumed by animals. The rate of production of edible forage equals the rate at which the edible forage is consumed by animals. Their death rates equal their birth rates and hence are stable in number.

**B) Economic carrying Capacity**

This refers to that herbivore density that corresponds to the maximum sustainable yield. Economic cc offers maximum economic returns and unlike the ecological cc it is determined by the objectives of the producer.

**4.2. Conceptual stocking strategies for pastoral rangelands**

**Productivity and carrying capacity relationship**

There is a fundamental trade-off between gain per animal and gain per unit of area. At very low stocking rates animals can selectively forage with little competition from each other. This ***promotes high gain or high body condition of individual animals but does not result in*** ***maximum productivity per acre.***

As stocking rate increases competition between animals for forage increases resulting in ***a decrease in individual animal performance***. At heavy stocking rates individual animal performance also decrease because lower quality plants make up a larger portion of the diet and total intake can be reduced. Between the extremes of light and heavy grazing there is an optimum stocking rate ***that maximizes productivity per acre.***

**Potential Effects of High Stocking Rate**

1. Animal performance reduced
2. Intake and forage quality reduced
3. Desirable forage plants replaced by less desirable species
4. Overall forage productivity reduced
5. Increased replacement feed costs
6. Potential for water quality impacts due to increased bacteria, sediment, and nutrient loading
7. Increase in bare soil and preferred grazing areas become degraded

**Potential Effects of Low Stocking Rates**

* Economic potential not fully realized, enterprise sustainability at risk
* Mature animals maintain over-fat body condition which can reduce reproductive capacity
* On perennial dominated rangelands patchy grazing results in development of ―wolfy‖ plants that are used little or not at all. This reduces overall productivity. This occurs less in annual dominated rangeland types but under used patches of less desirable vegetation may occur.
* Some desirable forage species can be crowded out by taller growing species
* Reduced biodiversity of species that thrive under moderate grazing

**4.3. Approaches to estimating carrying capacity of rangelands**

When stocking rate calculation for a given range unit is planned, certain points that critically affect it should be considered. These points include the following:

1. How much forage is produced during the year and how much of this is available for livestock consumption (available forage) and
2. How much forage is required by the type and class of animals raised (forage demand)
3. How long animals will be using the area under consideration (duration of grazing).

**1. Forage demand:**

Wide range of studies that were consistent is showing that range ruminants consume 2.5-3% of their body weight per day in dry matter when forage availability is not restricted. Intake may go as high as 4% body weight when the forage quality is high. An animal is assumed to consume from 2.5-3.0% of its body weight each day. The animal which have 250 kg body weight consumes about 6.25-7.50 kg dry mater feed per day per animal. In a year this animal is expected to consume 2281.25 kg feed for maintenance However, the requirement may range from 2.3 to 2.7 ton of dry feed per annum).

**3. Forage production (Available forage):**

The next consideration in determining stocking rate is the amount of forage produced that is available to grazing animals.

**Materials needed:** Simple tools such as a gram scale, clippers, paper bags, and a Hoop or frameof known area (e.g. 1m2) are all that are needed to determine the amount of forage available for grazing. Sites that have many forage species or that are sparsely vegetated require larger hoops to capture and reflect this variation in the collected samples. Alternatively, taking more samples with a smaller hoop can also increase the accuracy of the estimates.

***Step 1: Weigh empty bags.***

Record the weight (in grams) of an empty sampling bag (be sure to use the same kind of bag for all samples.

***Step 2: Toss hoop and clip forage***

Choose an area that is generally representative of the whole rangeland to be surveyed (i.e., similar soil, vegetation, topography). Randomly toss the hoop and let it lay flat on the ground. Clip all vegetation within the hoop to the ground or to the root mat layer. Discard weeds, soil, roots, or other materials that are not forage species, and place the remaining forage in the bag. Repeat this process until you have at least four samples.

***Step 3: Weigh clippings and adjust for dry matter content.***

Weigh the bags containing the clipped forage and record the weight in grams. Subtract the weight of the bag from each sample to get the actual weight of forage. Calculate the average wet weight of the samples for the pasture. Dry weight values are more useful for determining forage production and in setting a stocking rate because plant tissue water content varies widely, and the dry portion represents the nutritionally important material.

***Step 4: Determine kg per hectare.***

Lastly, convert the average dry weight per hoop to kg per hectare. This will give the average forage production in kg per hectare on a dry-weight basis, which is necessary for determining the appropriate stocking rate.

**Example 1. Determining forage production:**

To determine the average forage production of 3-hectares rangeland on his ranch, ranch manager clipped four forage samples from a 1m2 hoop in an ungrazed area. The entire rangeland has similar soil and other characteristics. The samples are largely composed of Rhodes grass with a well-established mat. Forage samples in each hoop were clipped down to the mat layer, which represents the amount of forage available for grazing. Line A gives the fresh sample weights in grams, and Line B gives the bag weight in grams.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample: | 1 | 2 | 3 | 4 | Total |
|  |  |  |  |  |  |
| A. | 250 | 225 | 270 | 230 | 975 |
|  |  |  |  |  |  |
| B. | 25 | 25 | 25 | 25 | 100 |
|  |  |  |  |  |  |

C. Total wet weight of forage (A total – B total = C), C = 875(975-100)

D. Average wet weight (C ÷ 4 = D), D = 875 ÷ 4 =218.8

E. Average dry weight (for Rhodes grass, E = D × 0.25), E = 54.7gram (this is by assuming that Rhodes grass has 25% dry matter).

Then calculate kg per hectare as follows: Since 1 hectare is 10,000m2 from the hoop or from 1m2 we will get 54.7 gram, so from 1 hectare or from 10,000m2 we will get, 10,000m2 x 54.7gram=547000 gram=547 kg. So, from 3 hectare we will get 3X547kg/hectare=**1641kg** dry matter Rhodes grass.

**To calculate an appropriate balance between forage supply and demand three multipliers are additionally require adjusting for:**

1. Grazing efficiency (the proportion of total herbage livestock can harvest). This is because all herbivores are not similar in harvesting efficiency of all available forage. For example sheep are more efficient than cattle.
2. Forage loss due to trampling, fouling, and decomposition.
3. Proper use, which is the maximum proportion of herbage that can be harvested without causing rangeland degradation. In other words, the amount that should be left after grazing as residue for the next growing season (Amount required for re-growth of plant post defoliation).

Although each of these three factors needs consideration, most estimates have used a single multiplier that combines adjustments for all. This multiplier, however, is little than an educational guessed and there is inconsistency in the literature. Some have guessed this at 40-50%, others 30%, 30-45%, 25-30% etc. Therefore, the general consensus is that takes a higher figure for more humid areas and lower figure for dry areas (25-50%).

Often carrying capacity is estimated from average annual productivity. To calculate carrying capacity you need to determine the ***total available forage*** in the pasture and you need to determine ***animal demand for forage***. Finally you may need to adjust your carrying capacity estimate for steep slopes and distance to water.

**a. Adjustment for distance from water**

If stocking rate calculated for a range is not adjusted for travel distance to water, it may lead to considerable range degradation, especially around watering points. This adjustment is particularly useful for cattle, for sheep and goats do not require water every day. Cattle make little use of areas further than 3.2 km from water and hence adjustments are needed.

|  |  |
| --- | --- |
| Distance from water (km) | Reduction (%) |
| 0-1.6 | None |
| 1.6-3.2 | 50 |
| >3.2 | 100 |

However, note that this is only a guiding principle as animals can walk long distances and graze furthermore, practical experience is more important.

**B. Adjustment for slope**

On rugged terrain rangeland overgrazing and deterioration often occur on the flatter, more convenient sites even though the total forage supply is adequate. Sheep and goats make much better use of rugged terrain than do cattle because of their smaller size, greater surefootedness, and a stronger climbing instinct (goats), they naturally use steep areas. Sheep can use a slope of up to 45% while slopes exceeding this are considered as non-usable by sheep. For cattle this adjustment is as follows:

|  |  |
| --- | --- |
| Slope (%) | Percent reduction |
| 0-10 | None (all forage produced is usable) |
| 11-30 | 30 (only 70% of forage produced is usable) |
| 31-60 | 60(only 40% of forage produced is usable) |
| > 60 | 100 (ungrazable area though it produces forage) |

Note that this is only a guiding principle as animals can also graze on steep slopes thus practical experience is most important.

**4. Unit time**

Once the carrying capacity has been determined for a particular ranch, the amount of time a group of animals spends in each pasture should be determined to complete the process of setting a stocking rate. Operations that use large pastures or grazing units will typically find basing stocking rates on months or years more useful.

**4.4. Appraisal of applicability of carrying capacity to different settings**

**Calculation of stocking rate**

**Case 1**

***Assumptions:*** based on information from the Natural Resources Conservation Service and ourown observations, production of key forage species averages about 700 kg/ha of dry matter (DM) per year. The ranch is 2,000 ha in size.

**Question 1:** How many 400-kg cows can we have in our base herd?

1. **total usable forage:**

**Total forage (kg) available for grazing** =

Forage production (kg/ha) x % allowable use X are

a (ha)

**700 x 0.50 x 2,000 ha = 700,000 kg**

1. **forage demand**:

Forage demand/cow/year = Weight of cows (kg) X daily DM intake (2% body Wt) X number of days range will be grazed (365).

=400 x 0.02 x 365= 2,920 kg of forage /cow/year

**C.** **stocking rate:**

Number of cows pasture will carry = total usable forage (kg) ÷ forage/cow/year

* 700,000 ÷ 2,920
	+ **240 total cows**

One bull is recommended per 20 cows. Therefore, this range would support a base herd of about 228 cows and 12 bulls

Number of bulls = 240 ÷ 20 = 12

Then, 240-12 = 228 cows. Therefore in total the ranch can hold 228 cows and 12 bulls.

**Question 2:** If sheep (ewes) were substituted for cattle, the number of sheep in the base herd(assume that sheep weigh 65 kg) would be calculated as follows: Answer:

1. **Available forage. It is the same as used previously i.e. 700,000 kg**
2. **forage demand**: Forage demand/sheep/year =

Weight of sheep (kg) X daily DM intake (2.5% body Wt) X number of days (365) =65 x 0.025 x 365= 474.5 kg of forage /sheep/year

1. **stocking rate:** = total usable forage (kg) ÷ forage/sheep/year

= 700,000 ÷ 474.5 = **1475 sheep**.

**Question 3:** If this range were used for only 9 months, the total number of cattle would becalculated as follows:

1. **total usable forage:**

**Total forage (kg) available for grazing** =

Forage production (kg/ha) x % allowable use X area (ha)

* + **700 x 0.50 x 2,000 ha = 700,000 kg**
1. **Forage demand**:

Forage demand/cow/9months =

Weight of cows (kg) X daily DM intake (2.5% body Wt) X number of days range will be grazed (365).

* + 400 x 0.025 x 270 days= 2,160 kg of forage /cow/9months

**f. Stocking rate:**

Number of cows pasture will carry = total usable forage (kg) ÷ forage/cow/9months

* 700,000 ÷ 2,160
	+ **324 total cows**

**Case 2**

**Question 4:** Condition of the range is poor. Although the terrain is rugged, water is welldistributed. You graze this range for 4 months. Production of key forage species average is about 200 kg/ha/year. Area is 1,000 ha; Slope on this range is as follows: 40% of the range has 0-10% slope, 20% has 11-30% slope, 30% has 31-60% slope, and 10% has over 60% slopes.

**Question 4a**: How many 400-kg cows could you have in your base herd?

1. **Total produced forage:**
* Total forage = forage production x area = 200 x 1,000 ha **= 200, 000**
* but, not all of the forage is accessible to livestock because grazing access is restricted by slope:
	1. 40% of the range has 0-10% slope (100% accessible)
		+ 1,000\*40%\*200x100% = **80,000** kg
	2. **20%** has 11-30% slope (70% accessible**)**
		+ 1,000 \*20% \* 200 \* 70% = **28,000 kg**
	3. **30%** has 31-60% slope (40% accessible)
		+ 1,000 \*30% \* 200 \* 40% = **24,000 kg**
	4. **10%** has over 60% slopes (0% accessible)
		+ 1,000 \*10% \* 200 \* 0% = **0 kg**
		+ 80,000+28,000+24,000+0 = **132,000 kg** forage is accessible **b. Calculate usable forage by adjusting for allowable use:**
* Usable forage=total accessible forage x allowable use

 = 132,000 kg x 25% = **33,000** kg forage available for use

1. **Forage demand**:
	* Forage of days pasture will be grazed (120 days).
	* 960 kg of demand/cow/120 days = weight of cows (kg) X daily DM intake (2% body wt.) X number forage /cow/120 days = 400 x 2% x 120
2. **Stocking rate:**
	* Number of cows pasture will carry = total usable forage (kg) ÷ forage/cow/120 days

33,000 ÷ 960 = 34 **cattle (2 bulls and 32 cows**

**CHAPTER 5. RANGE UTILIZATION, CONDITION, AND TREND ANALYSIS**

**5.1. Utilization Measurements**

Utilization (degree of use) refers to the proportion (usually percentage on weight) of current year forage production that is consumed and/or destroyed by grazing animals. Utilization may refer either to a single plant species, a group of species, or the vegetation as a whole. This process requires a comparison of the amount of herbage left compared with the amount of herbage produced during the year. **Percent utilization on weight basis=biomass removed /Biomass** **produced\*100%.** The concept of utilization is important for the proper management ofrangelands. Its measurement enables the manager to evaluate the effectiveness of the current year‘s grazing season. Thus, it gives the manager a chance to early correct under or over use of the rangeland. Utilization measurements have many uses in grazing management including that of making short-term and long-term adjustments in stocking rates. Other uses include assessing physiological proper use, monitoring the adequacy of grazing distribution, determining key management areas and key species, determining the efficiency of forage-herbivore conversions, and evaluating grazing treatment effects. The need for measuring utilization is in general crucial because, the quality and quantity of plant re-growth is largely dependent on the amount of biomass harvested in the previous year (in the past grazing calendar). The way range plants are used determines the improvement, maintenance, or deterioration of the range. Previous patterns of range utilization determine future improvement maintenance, or deterioration of the rangeland. The final aim of measuring utilization is to estimate the **proper use factor for the** **range**. This proper use of plants is fundamentally a physiological problem the solution of whichlies in the plants ability to fulfill the functions of root growth, water storage, and reproduction.

**5.1.1. Measurement options of utilization**

There are different options developed to measure utilization and the preferences for a particular method largely depends on the purpose of measurement, labor cost and availability and the type of vegetation.

Any method of measurement should be:

* Easy to be applied by the inexperienced person
* Requiring minimum equipment
* Rapid (Fast enough to cover large areas in short time during and at the end of growing periods).
* Reasonably accurate and precise as it involves animal number adjustments.

**5.2.1. Ocular method**

This involves estimation of the herbage removed in terms of weight. Utilization estimation by ocular method as the name indicates it is a simple **eye estimation of the amount removed** (of course simple for the experienced manager). Estimates are checked against actual weight. The percentage by weight of forage removed is determined (estimated) **for individual plants of the key species** or **from all plants of the key species within small quadrats**. If quadrats are to beused for the studies, use quadrats of the same size. The quadrats should be small enough so that the entire quadrat is clearly visible to the examiner.

**To do this:**

1. Find an ungrazed area or several ungrazed plants

2. Set plot of select individual plants (depending on method to be used)

3. One person clip (not the ground level) part of the plot/plant to simulate grazing. Weight the amount removed (portion A)

4. The other person should estimate the % utilized from the plot/plant.

5. Clip and weight the remainder of the plot (portion B)

6. Calculate % utilization =$\frac{A}{A+B}\*100$

Reliability can be improved by clipping and weighing on several plots repeatedly. Example: if the first clipped biomass is estimated to be (the actual weight of this is) 3 kg and that of stubble 6kg, then actual weight removed is 3+6=9kg. Utilization= (3/9)\*100% =33%. Ocular method is suitable for grass, forbs, and shrubs for general field use. The most important advantage is speed; the method is reasonably accurate, depending upon the ability of the examiners.

**5.2.2. Paired Plot**

Under the Paired Plot Method, forage from protected and unprotected plots is clipped and weighed at the end of the use period. The difference between these two weights represents the amount of forage consumed or otherwise destroyed during that period. This system uses device like **cages and enclosures**.

Cages are used for short–term monitoring, whereas enclosure areas are used for long term monitoring since cages have micro environmental effect on growth and yield of forages inside the gages as compared to that of the outside. First we need to define the area of sampling. Then within this area Similar paired plots in vegetation composition growth etc. will be selected. Then, randomly assigned any of plots to be caged and the other left open for grazing (not caged). Many paired plots will be used and we will take the average. Allow the animals to graze freely for 2 or 3 months. After the grazing period go back to the field and clip all the biomass both in the caged and grazed plots and put the samples separately (it should be clipped to the ground level). In this case, the enclosures are clipped to compare with similar plots on adjacent grazed area. Then, dry it in the oven and weigh. The difference in weight between the caged and grazed plots is considered to be the percentage of utilization. Both grazed and ungrazed will be clipped and weighed averaged and the difference is then calculated as:

**Grazed weight/ungrazed weight x100%**

Example1.

**Pair 1** Forage production of ungrazed=200g, Forage production of grazed 140g.

Difference=200-140=60g; %Utilization=average difference/total annual productionX100

60g/200\*100=30%

**Pair 2** Forage production of ungrazed=180g, Forage production of grazed 150g. Difference=180-150=30g %Utilization=average difference/total annual productionX100 = 30g/180gX100=16%

Example2:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Ungrazed (Caged | Grazed plot Wt in | Wt difference | % utilization |
|  | plot) weight in gram | gram (B) | (A-B) | (A-B)/A\*100 |
|  | (A) |  |  |  |
| Pair-1 | 89 | 64 | 25 | 28.08 |
| Pair-2 | 108 | 89 | 19 | 17.59 |
| Pair-3 | 76 | 46 | 30 | 39.42 |
| Pair-4 | 64 | 48 | 16 | 25.00 |
| Pair-5 | 93 | 60 | 33 | 35.48 |
| Pair-6 | 81 | 59 | 22 | 27.16 |
| Pair-7 | 66 | 38 | 28 | 42.42 |
| Pair-8 | 90 | 71 | 19 | 21.11 |
| Pair-9 | 129 | 89 | 40 | 31.01 |
| Average | 88.44 |  | 25.77 | 29.7% |

Utilization%=average difference/Average total annual productionX100%

**% utilization = 25.77/88.44\*100 = 29.15%**

This method should be used carefully:

* It measures both yield and utilization. That being the case if we want to be accurate, large number of plots is needed.
* When we locate and setting cage we should be careful not to make the caged plot different from the grazed plot. We need to use materials that do not create differences
* A common objection is that differences in growths between caged and grazed area may distort utilization estimate. The greater the period of time between caging and clipping the larger this becomes because there is regrowth in the grazed plants (because of difference in the growing period during which caging and clipping are undertaken continuously).
* This method is a simple and direct way of measuring utilization.
* Little training is required and accuracy is generally high.
* This method is time consuming, and ungrazed areas that are protected from foraging are required (limitation).
* Where periods of use are long, this method does not provide information about the cumulative production of foraged plants unless the cages are moved at short time intervals.
* This method is suitable for all vegetation growth forms for which production and utilization data are commonly desired. It is particularly applicable where periods of use are short, use is relatively uniform, and regrowth after foraging is not significant.

**5.2.3. Weight Before and After Grazing**

This involves measuring plant unit weight before and after grazing. The plant unit is an easily differentiable and recognizable portion of the individual plant. This could be a single stem or entire plant and should be large enough so as never to be entirely consumed, since after grazing units must be collected to determine the percentage removed by the grazing animal. The method is best adapted to range grazed for short period of time where regrowth is not a factor. Example routs that can continuously use by moving animals in which case the vegetation utilization could be estimated. The unit selected may include more plant material than is actually represented in the current year‘s growth (its weakness).i.e. more sample is required as compared to paired plot since grazed and ungrazed are not necessarily similar in this case. Here cages are laid without taking time for locating its pair. Grazed plot is placed not necessarily the same with the caged plot. Then utilization will be calculated by average biomass from the caged plots minus average biomass from non-caged plots and dividing the difference to the average biomass of caged plots.

**5.3. Range Condition Assessment Approaches and methods**

Range condition is the current productivity of a rangeland relative to what that range is naturally capable of producing. Range condition is used as a guide to ensure sustainable land use, to determine [carrying capacity](http://globalrangelands.org/inventorymonitoring/carryingcapacity) and adjust [stocking rates,](http://globalrangelands.org/inventorymonitoring/stockingrate) to identify potential responses to range improvement programs such as brush control or reseeding, and to evaluate the best locations of fences and water facilities to improve [utilization](http://globalrangelands.org/inventorymonitoring/utilization) within a pasture. Range condition measures the degree of range deterioration and improvement. It evaluates present range production in proportion to production potential. The two commonly used approaches to assess conditions of rangelands are ecological or quantitative climax and site potential approaches.

**a) Ecological approach**

This method compares species or [species groups](http://globalrangelands.org/inventorymonitoring/groups) in the existing vegetation with that expected in the climax vegetation, to give a percentage reflecting the similarity between the two. A value close to 100% indicates that [species composition](http://globalrangelands.org/inventorymonitoring/composition) of the existing vegetation closely reflects the composition of the climax vegetation, whereas lower values indicate a greater level of departure from perceived climax conditions. This requires knowledge of climax vegetation and succession. Condition classes are assigned according to the percentage of the **climax vegetation**. From plant composition we can judge range condition by comparing the expected percentage of the climax composition distribution by each species to the actual composition. Most range sites descriptions are based on **% by dry weight**. Therefore, composition techniques based on biomass are most appropriate. It is possible to drive numerical value which indicates the degree of departure of forage from climax and thus its condition rating. This index includes all decreasing climax species, that portion of the increasing climax not in excess of the climax percentage and no invaders.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Range condition |  |  | Index |  |  |
| Excellent |  | 76-100% of Climax |  |  |
| Good |  | 51-75% of Climax |  |  |
| Fair |  | 26-50% of Climax |  |  |
| Poor |  | 0-25% of Climax |  |  |
|  |  |  |  |  |  |  |

Thus **excellent, good, fair and poor range condition** evaluates the state of the range against a certainstandard (climax). Climax composition can be known by using historical record or by using bench mark site. The manager must evaluate moderately **grazed areas, enclosures, riversides,** **and changes in resources** following relief from over grazing. Before the application of thesecondition ratings to the whole rangeland, the range areas are broken into smaller less variable land units termed as ecological sites or habitat types. **Three criteria that enable to identify** **ecological sites (habitat types)** are:

* Difference in composition and proportion of the species groups in the community
* Difference in soil characteristics, climate (rainfall), and topography leading to significant difference in production.
* Difference in land use potential and subsequent hazards (example hillsides, riverbanks, etc)

**To determine range condition the following procedures and information must be known or available.**

1. Identify the plants that are present and classify them as to reacting to grazing (decreasers, increaser, and invader).
* **Decreaser (palatable grasses)** these are desirable grass species which are likely to bereduced by continuous heavy grazing. This is a plant that is reduced in numbers or composition as a result of heavy grazing. Some of the decreasing species are *Themeda* *triandra, Crysopogon spp., Panicum spp., etc.*
* **Increaser (moderately palatable spp.)** These species are less desirable grasses which willinitially replace decreasers that disappear by heavy grazing. Some of the increasing species are *Bothriocloa spp., Eleusine jagri, Cymbopogon validus****, etc.*** This is a plant that increases in percentage of composition during the first part of heavy grazing as the range condition is on the decline. Continued heavy grazing will cause these plants to decrease in composition.)
* **Invaders or pioneer (indicates a bad range condition)**

These are less desirable plant species that replace increasers. These grasses and weedy forbs are unpalatable and have no grazing value whatsoever. This is a plant **not present** under an ideal **climax condition or only present in small amounts**. These plants increase in composition on extremely heavy grazed range or one that is deteriorating.

1. Name the range site which is being considered.
2. Estimate the percent air-dry weight that each species contributes to the total production. i.e. mark out a plot and clip off, by species, all of this year‘s production, dry and weigh it.
3. Determine the percent of each plant which can be counted toward the condition class form.
4. Add up the amounts you recorded.

**b) Site Potential**

The use of site potential of an area in terms of forage for animals has been suggested as an alternative to the ecological approach based on proportion of climax vegetation. The approach presupposes knowledge of the potential of the site for forage production. The approach **rates a given site in terms of current forage production** and its potential under sound management practices. The different forage types are differentiated into desirable, less desirable and undesirable groups and rating is based on the proportion of these groups. These ratings are:

* **Excellent** condition range that has the capability (potential) to produce 90 to 100%of all the forage possible under sound and potential management
* **Good** condition range productivity = 70-90%
* **Fair** condition = 50-70%
* **Poor** condition = 25-50%
* **Very poor** condition = < 25%

 These are percentage composition of desirable species, density of plants, vigor (which is the health and thriftiness of plants), litter accumulation and decomposition rate, degree of soil erosion which all can be used in different combination in different range areas. **In short,** condition rating is based on the current forage production of a site in relation to its potential under sound management.

**5.4. Definition and its Relation to Succession**

***Plant succession***: involves the replacement of one plant community by another until the finalcommunity is reached. This final, somewhat stable community is called the ***climax***. **Climax** **vegetation** is the final stable community that results after a serious of changes (succession).Vegetation is never stable; between there is continual change in growing conditions, which will cause a continuous change in species composition. The term climax vegetation had better be reserved for physiognomic vegetation type, without detailing the species composition. The climax can then be a forest or grassland, within which species composition exhibits changes around equilibrium. There are two kinds of succession: Primary succession is those starting from bare ground and open water (primary areas) and proceeds to the development of somewhat stable climax vegetation. Secondary successions are those following some type of disturbance like fire and heavy grazing. Vegetation disturbed by grazing, tree cutting or agriculture, has a natural tendency, if protected from further disturbances, to change in composition and structure back toward a more stable (or climax) state through a process known as secondary succession. Range managers routinely deal with secondary succession since it deals with vegetational changes and how these changes influence habitats for other organisms. Occur much faster than primary succession and can be predictable.

Current approaches to rangeland condition assessment have their roots in the observations of secondary succession to range condition classes produced by livestock grazing. Heavy grazing caused a shift to lower successional stages and reduction or absence of grazing allowed succession to proceed to higher stages. **Current approaches to rangeland condition rely on** **comparisons of species composition (relative biomass) of present vegetation compared to the "climax" or "potential natural" vegetation for the site.** Vegetation is rated as poor, fair, good, excellent according to its similarity to the climax. Implicit in this approach is that "**climax" or "potential natural**" vegetation is best in terms of stability, diversity, and productivity. Departure from the climax, or retrogression, is generally attributed to livestock grazing and occurs as a result of "years of overgrazing or of "grazing intensity. Reduction or elimination of grazing will result in succession to a higher condition class, ultimately reaching "excellent" or "potential natural" condition. This model reflects a linear, reversible reaction of vegetation to the "disturbance" of grazing.

**5.5. Range Trend Determination**

Range trend indicates **the direction of change in range condition** and is usually expressed as improving, declining, or stable**.** Range condition alone is not an accurate indicator of correctness of current management practices. This is because rangeland vegetation often is not static but changing in some way. Thus range management decisions based solely on the results of a survey of range condition. For instance, the management implications of say, a stable rangeland in good condition and one that is also in good condition but it is in process of changing toward a poorer condition rating, may be quite different. In the former case the existing management regimes appears to be working whereas the latter case implies the need to modify management inputs so that the downward trend can be counteracted. Therefore, an early awareness that change is occurring is important because it provides the opportunity (time) to either stop/ reverse undesirable changes or takes advantage of desirable changes.

Range trend assessments depend upon evaluation of the general health of individual plants, the total vegetation and the soil. Perhaps the most useful factor indicating range trend is **reproduction** of the desirable species. Young, medium-sized and large grass plants indicate thatthe species is regenerating and that the stand is maintaining itself. In this case the trend is static or improving. In tropical regions, where range management is a new science, relevant background information is difficult to obtain. There are basically two ways to measure trend**:**

1. **Monitor range condition over several years**. Range trend monitoring is carried out byperiodic re-measurements of vegetation and soil attributes at the same location at different time.
2. **Apparent trend can be detected by looking at plant and soil characteristics.**

Downward Trend

* Better forage plants unavailable to livestock.
* Hedged and high lined shrubs
* Dead and dying hedged plants
* Lack of reproduction of young plants of desirable species
* Invasion by undesirable plants.
* Desirable plants lacking vigor
* Scarcity of litter of desirable plants
* Rill marks.
* Small active gullies of the shoestring type.
* Active gullies.
* From a few inches to several feet deep.
* Alluvial deposits lay down by running water.
* Absence of perennial vegetation on the deposits.
* Exposed plant crowns or roots.
* Wind scoured depressions between plants.
* Wind deposits.
* Fine soil particles drifted into the vegetation.

**Upward Trend**

* Better forage plants invading and readily available to livestock &wildlife
* Invasion of plants into eroded areas.
* The basal parts of plants flush with the ground surface.
* Several years‘ growth from hedged browse
* At least 2 or more years of regrowth evident
* Desirable plants vigorous
* Many leaves, seed stalks tall and numerous, leaves a healthy green color.
* A variety of age classes of desirable plants
* A well dispersed accumulation of litter from past years growth.
* Gullies healed.
* Perennial vegetation on both sides and bottom
* Plant roots are covered by soil.

**CHAPTER 6. RANGE VEGETATION REHABILITATION AND**

**IMPROVEMENT METHODS**

Once adequate information is gathered on rangeland condition/trend and confirmed that the rangeland needs further improvement, then the next issue becomes how to rehabilitate this. The techniques used to rehabilitate and improve range vegetation vary based on several factors such as environmental, climatic, socio-cultural, economic, and technology**.**

**6.1. General Considerations in Rehabilitating Rangelands.**

Because of high cost and the low and slow returns involved, before the application of any rehabilitation technique or practice, certain points should be bear in mind. These include resource status assessment and site evaluation, identifying and understanding the root causes of the problem and controlling mechanisms (after correcting the problem what measures can be taken), prediction and evaluation of benefits and risks (impact assessment) on other components of the system (that could result from its application), adaptation to site and use socially and technically. **Resource** assessment includes description of the physical and biological attributes or characteristics of the site with its historical and current uses. This assessment enables the range manager to determine the nature and condition of resources to be improved, identify areas of priority concern, identify the relative importance of each area in relation to objectives, and develop plan of action. The assessment results are given in map (<1:100,000 scale) and reports.

To correct the problem that initiated rehabilitation, all possible causes must be explored and possible mechanisms of preventing them from happening again should be devised from the outset.

**Range improvement programs:** Programs are classified into **four categories** depending on theobjectives.

1. **Rehabilitation** of degraded rangelands (bush encroachment, etc.) for forage and wildlifehabitat improvement.
2. **Modification** of range practices such as grazing management, multiple use, forestmanagement to maintain or improve productivity of ecosystem.
3. **Enhancement of existing forage** (feed) and habitats through maintenance, burning,fertilization, soil conservation, or reseeding/planting to increase the density of existing species.

**(iv). Manipulation of animal numbers and distribution u**sing grazing systems, herding,fencing, etc.

A properly planned range improvement programs generally increase the potential production of the ecosystem: Increase forage quality and quantity, Increase livestock and wildlife production and diversity, Control undesirable plants, Reduce wildfire hazards and Improve overall economy of the operation

**6.2. Rehabilitating methods**

Rangeland improvement programs will be achieved through:

* Propagation of new plants
* Release of existing plants by eliminating undesirable competing species
* Protection of existing habitat from such factors as overgrazing

In general, the most commonly and frequently used improvement options for rangelands are:

seeding/reseeding, development of water points this is done together with grazing systems improvement), control of bush encroachment by using fire, mechanical means (using heavy machinery), chemically and biologically, and the promotion of different physical soil and water conservation measure (all these followed by proper grazing management and fertilization).

**6.3. Seeding/Reseeding**

Re-vegetation is the critical key to the renovation of many rangelands of relatively more humid areas. A cover of vegetation supplies dependable feed for animals keeps the soil and water in place and decreases evaporation and runoff by increasing percolation and soil storage of rainfall. It shelters the soil from scouring and provides a barrier that slows runoff. This re-vegetation is possible both by natural processes (its effect is not extensive) as seed dispersal by wind, birds, and other animals, or carried by seasonal streams and flood waters; planting by human activity, deliberate or unplanned also promotes new growth. Planned revegetation has two components**:**

1. **Direct sowing by seeding or planting trees, shrubs, and grasses** using a variety oftechniques.
2. **Management interventions** that serve to strengthen the role of natural revegetationprocesses. Example: protection improvement in grazing systems (e.g. deferred rest etc).

**Factors to consider when planning reseeding of degraded rangelands**

Before the *actual seeding or reseeding*, climatic and topographic requirements, degree of deterioration and the composition of desirable species in the current vegetation, seeding rate determination, the use of common grass seeds for denuded lands, charges in management of the seeding site, cost, expected returns and risks must be considered.

**6.2. Grazing Management**

All desired grasses decrease in numbers with continuous grazing, overgrazing, or abuse. Undesirable plants will invade immediately. Each grass plant has its growth and grazing characteristics. Proper management practices should be used to maximize the use of each grass. Most range plants provide quality forage and are eaten by some class of livestock during the year. In an overgrazed pasture, 45-70% of the rainfall is lost to runoff. In a properly grazed pasture, only 10 percent or less is lost to runoff.

Proper grazing use allows the land to be grazed at an intensity that maintains enough cover to protect the soil, while maintaining or improving the quantity and quality of the desired vegetation. A rule of thumb for proper grazing use is to "take half and leave half" of the available forage during the growing season. Livestock can graze a plant down to half its weight, which is generally about two-thirds of the mature height, without detrimental effects to the plant.

Grazing management broadly speaking is the manipulation of grazing animals to achieve desired results. The essentials of grazing management required **to obtain the optimum utilization of** **forage resource** can be categorized into four basic principles of grazing management**:-**stokingrate, season of grazing, distribution of grazing across landscape and match kinds and classes of animals with the rangeland vegetation, topography and climate.

**1. Proper stocking**

This is probably the single most important factor involved in grazing management. Most range plants are well-adapted to tolerate grazing, but they do have limits as to frequency, intensity and season of utilization. Example, overstocking is a common livestock production practice used in most parts of the rangelands of Ethiopia but it is a serious problem in the Afar and Somali rangelands creating imbalances in the use of natural resources. Overstocking is the result of pastoralists using grazing land communally without limiting livestock numbers. Other major reasons for overstocking include:

* Low productivity of animals. This forces pastoralists to keep a large number of stocks in order to meet their subsistence requirements.
* Pastoralists inhabit in areas where rainfall is erratic and scarce. Therefore, drought is a recurrent phenomenon. This situation compels them to hold buffer stock above their subsistence requirement.
* Large numbers of stock also serve as a hedge against losses due to deaths from diseases, raids, etc.
* A large number of livestock also confers better status in the society

Therefore, proper stocking involves obtaining the proper ratio between animal numbers and grazing forage, such that the animals can meet their intake requirements and the plants can meet their requirements for growth and reproduction.

**2. Proper season of grazing**

Some ranges are suitable for grazing during all seasons while others are accessible during certain seasons. Continuous grazing for consecutive years without resting the pasture results in deterioration of the range vegetation. Therefore, it is important to determine the seasonal suitability of the grazing land prior to developing the grazing management plan. Grazing distribution is always a factor in obtaining efficient utilization of available range resources.

**3.** **Distribution of grazing across landscape**

Animals never graze vegetation uniformly. The patterns of utilization which result may be classified as area selective and species selective grazing. Animals‘ selective grazing behavior results from the preference of animals for grazing in certain areas as opposed to other areas. Many factors cause area selective grazing. This includes size and shape of pasture, location of water, topography and other environmental factors. Livestock mobility and duration of grazing in a particular area is a key factor for proper utilization of available forage. Livestock mobility in this regard is a traditional form of pasture rotation grazing system, which discourages selective grazing and attempts to match the natural needs of the animals with the forage resource availability in different areas. However, its intensity depends on the animal concentration and grazing lands in a particular area. The distribution of water points and the timing of their use have direct impacts on the condition and productivity of range plants. On the other hand, there are areas that are underutilized because of bad distribution or lack of adequate water for livestock, while areas around permanent water points can be heavily grazed.

**6.3. Development of Water Points**

In the open grazing system, water should be evenly distributed on the farm to avoid overgrazing and soil erosion around the water point. In areas where there is under utilization of range forage, the opening of new water points can lead to uniform utilization of the range land. However, the opening of unnecessary number of water points leads to range degradation as is witnessed in areas subject to ―water development intervention‖ by disrupting the traditional mechanism of water use (example Borena). The distance between water points should be neither too long nor short to affect animal production and rangeland condition.

**6.4. Control of Bush Encroachment**

Bush encroachment is an increase in invasive woody plants with a general decline in forage productivity. Bush encroachment leads to reduced grazing potential. It poses a threat to the conservation of biodiversity. Grasslands overall the world have evolved with fire. However, in East Africa, bush encroachment is a serious problem. Except in areas of very low rainfall or locally where soil water relations exclude trees and shrubs, the natural succession is believed to head towards woody vegetation. The reasons are mainly due to overgrazing and fire ban. One of the major threats of bush encroachment is reduction of grass production. For example, exotic and indigenous trees and shrubs are widely spread throughout semi-arid and arid zones of Ethiopia. Out of the exotic tree species *Prosopis juliflora* (Mesquite) is currently spreading and encroaching the grazing lands of Afar, Somali and Borana and is causing severe negative impacts on the production and productivity of pastoral areas. This species is spreading at an alarming rate into best grazing areas especially in the Afar rangelands. Other species such as *Acacia drepanolobium*, *Acacia seyal* and *Commiphora* species in Borana and *Opuntia* species, *Parthenium* species and *Lantana camara* are also causing serious problems by encroaching indry and wet season grazing areas.

**Bush control methods include:**

 Use of fire

 Mechanical control

 Chemical control

 Biological control

**1. Prescribed Fire**

The use of fire as a cheap bush controlling management tool is one of the controversial subjects in range management. This controversy arises because of over generalization (professional biasness) of its effects without describing the intensity and frequency of its occurrences. Besides, there are contrasting views among the range managers, foresters and environmentalists on the use of prescribed fire on rangelands. Despite these controversial issues about the use of fire on rangelands, from animal production point of view the primary advantage of burning, as a method of bush control is the low capital outlay involved. Prescribed or controlled burning is a cheap and very useful method of bush control.

**OBJECTIVES IN THE USE OF FIRE**

Primitive man used fire as a tool with which to manipulate vegetation and animal populations for his benefit. Modern man has developed public attitudes and has built a firefighting organization aimed at eliminating and controlling fire on wild lands. This organization is highly effective, but it has not achieved full control of wildfire.

Increasingly, rangeland managers are making use of prescribed fire as a tool. As might be expected, the objectives of these persons vary widely as to kinds of conditions they hope to develop, to maintain, or to prevent with fire. Effects of burning are many and most have been stated as objectives of prescribed fires, although they may have no more than a minor impact.

**To Alter Vegetational Composition**

This objective comes in numerous forms, such as removal of undesirable shrubs and herbaceous species, less competition for desirable species, to favor certain plant species, and "to restore the ecology." Perhaps it is the most common purpose of prescribed fire in natural vegetation.

***To Increase Livestock Forage and facilitate Management***

Reduced cover produced by burning facilitates movement and visibility for the traveler. Hunters prefer relatively open vegetation. Their uses of land and hunting success are directly related to accessibility. Few modern hunters camp, hunt, and hike in dense brush and forest when openings and edges are available.

Access is important to the modern land manager and administrator. Livestock control is difficult in dense vegetation. Openness in the forest understory facilitates timber inventories and sales. Viewing natural landscapes requires openings. Various reasons exist for maintaining open vegetation with prescribed fire.

**To *Increase Quality of Forage for Livestock***

Where grasses are tall and the mature herbage unpalatable, it may be necessary to burn accumulations of undecomposed old growth. Burning of *some forage species* improves the quality of forage.

**To *Prepare Land for Seeding***

Prescribed fire is used to prepare sites for and to encourage regeneration of many desirable plant species.

***Burning to Manage Wild Animals***

Control of tsetse flies, other insects, ticks, and reptiles has been attempted with burning. **In** tsetse fly reduction schemes in Africa, the real purpose is to change the fly's habitat from brush/grass or woodland **to** grassland. The fire itself kills few flies destroys ticks that are on the herbage at the time of the fire, and is only one of many methods used to combat them.

The following table shows the advantages and disadvantages of using fire to manage natural Pasture.

|  |  |
| --- | --- |
| **Advantage** | **Disadvantage** |
| To increase forage production by reducing competition for available water, nutrients  | Loss of plant biomass resulting in a short- term decrease in available forage |
| Controls bush encroachment, favoring growth of the herbaceous layer, which is important for livestock. | Increased danger of erosion |
| Rapidly mineralizes dead biomass making the minerals which were fixed in it available for plant growth  | Destruction of microorganisms near the soil surface because of increased soil temperature |
| Kills unwanted parasites such as ticks, tsetse | Loss of nutrients |
| Reduce high volumes of fuel, which reduce wild fire hazard. | Suppresses desirable species (depending on the plant community) |
| Prepare land for seeding. | Some soil microorganisms can be damaged |
| Reduce accumulation of litter which prevents growth plants and stimulate growth of desirable forage plants. | Frequent burning may eliminate important woody species from the area |
| Improve wildlife habitat by opening up dense plant cover while retaining diversity  | Poorly managed system damage range vegetation if burning is followed by untimely or intense grazing  |
|  | Poorly managed fire can quickly get out of control and cause devastating damage to property, people livestock and wildlife  |

**Fire characteristics**

Knowledge of fire behavior is essential to successful use of it in range management. As fire proceeds across a land escape, it responds to characteristics of weather and, topography and fuel.

**The factors that affect fire behavior and effectiveness are summarized below:**

1. Amount of combustible material/fuel load
	* Infrequent fires allow the buildup of fuel (plant biomass).
	* The greater the fuel load carried by an area the greater the intensity of fire
	* Important fuel characteristics include quantity, dryness, type and distribution
2. Short, small dry grass and fine dry shrubs produce intense fire
3. Large branches and fallen logs give slow, hot fire
4. Mixture of large and small/fine material produces ideal fuel.
* A grass cover in which a large proportion of the fuel is close to the ground usually gives better results than tall grasses with little foliage at ground level.
1. **Weather conditions**

The most important climatic factors that exert an influence on a fire‘s intensity include: precipitation, air temperature, relative humidity, and wind velocity.

**Precipitation** - this is in the form of moisture in fuel and acts in three ways:

* Because of its cooling effect, because heat is used to convert water to steam, thus reducing intensity of burning. For this reason water used to stop the fire should be directed at the fuel in front of the flame rather than on the flame itself.
* Moisture present in the air as steam or humidity reduces radiation, which retards drying of the fuel near the flame.
* Cooling reduces release of volatile and flammable oils.
* When temperatures are high, less heat is required to rise fuel temperature to the ignition point and for continued combustion as fire spreads.
* Higher air temperature produces intense fire and rapid spread of fire since it dries quickly the combustible material
* High humidity will greatly reduce the intensity of fire.
* Other conditions being equal, humidity decreases with an increase in temperature.
* The drier the air, the drier the fuels and the more likely prescribed fires will burn out of control.
* For this reason prescribed burning should not be attempted when the relative humidity is less than 25% and the temperature is above 24-27 ˚c
* When the relative humidity is above 50%, even a dense stand of dry grass will not burn satisfactorily, but when it is below 20% a good burn can be obtained from a patchy cover of partially green herbage.
* Burning should not be attempted when the relative humidity is above 40%, and for preference the figure should be 30% or less.

**Wind speed**- fuel combustibility increases with wind velocity, dries fuel ahead of fire

* Moving air brings o2 to the flames and removes co2 thereby increase combustion rate.
* It also moves hot air masses ahead of the flame where radiated heat dries and preheats new fuels ahead of the fire.
* At high humidity a steady breeze is necessary while at low relative humidity calm conditions are preferable.
* With low humidity and strong winds fire sweeps through the area too rapidly to have maximum effect and is more likely to get out of control.
* In many parts of east Africa the best combination of low humidity, low wind speed, and high air temperature occurs during the **mid to late morning** period.
1. **Topography-**
* Fuels on the up slope side of the flames are closer to the heat source and receive more radiant heat than do fuels on the down slope side.
* As steepness of the slope increases, rate of fire spread increases, hence chance for the fire to be out of control is high.
1. **Time and frequency of burning**
* Infrequent burning allows the buildup of fuel (plant biomass)
* Frequent regular fires prevent the buildup of fuel, and thus reduces the intensity of fire. It reduces the damage effects of fire.
* The timing of burn affects fire intensity through the moisture content of the vegetation at the time of the burn
* High residual moisture content present in vegetation early in the dry season results into less intense/cool fires
* Lower residual moisture in the late dry season allows a much fiercer, hotter and more intense fire.
* In terms of timing mid to late dry season will produce moderate and effective burning.

**Effects of fire on vegetation**

Fire may be beneficial or detrimental to a plant depending on it‘s:

* Timing: physiological state of the plant and season of the year.
* Frequency: refers to how often the same patch of ground is burnt
* Intensity: relates to the temperature, the fire reaches and the duration of the temperature at a particular point. It is a product of frequency and timing of burning and climatic factors.
* Physiology and growth stage of plants.

**Summary of effect of fire on sub-humid wooded savanna**

|  |  |  |  |
| --- | --- | --- | --- |
| **Season of** | **Intensity** | **Effect upon grass** | **Effect up on woody species** |
| **burning** | **of fire** |  |  |
|  |  |  |  |
| Early dry | Low | Harmful: because nutrients have not | Slight harm: because intensity is |
| season |  | yet been translocated to roots | low |
|  |  |  |  |
| Mid to late | High | Rarely harmful: at dormancy stage | Harmful: severe to very severe |
| dry season |  |  |  |
|  |  |  |  |
| Early rainy | Low or | Harmful: severe to moderate. Plants | Harmful: mid to light. No dense |
| season | High | mobilize their stored nutrients from | dry fuel for intense fire. |
|  |  | roots to above ground plant parts |  |
|  |  |  |  |

**Types of fire occurring in rangelands include:**

**Wildfires:** uncontrolled fires caused by either lightening or carelessness. It occursusually in dry season in areas where burning has been excluded for many years. These fires are damaging the ecology.

**Intentional fires:** location and time of burning have been determined. Little or noattempt to confine fire. Common among pastoralists to search for green and pest free pasture during nomadic movements.

**Preferred (Controlled) fires:** systematically planned burning where weather conditions,plant physiology, time and fire confinement are considered to promote greater benefitsfrom the burn. We will discuss this type of fire throughout this lecture.

**Prescribed (controlled fire)**

Prescribed fire is the skillful application of fire to natural fuels under conditions of weather, fuel moisture, topography etc, that will allow the confinement of fire to a predetermined area and at the same time will produce the intensity of heat and rate of spread required to accomplish certain planned benefits to one or more objectives of silviculture, wildlife, grazing, hazard reduction, etc. Prescribed burning is applied in rangelands to reduce woody vegetation and litter accumulation and it is recommended under the following conditions:

* When there is good fuel load (usually 1500kgDM/ha) and if it is dry
* Temperature should be between 28-35oC
* Humidity = 25-35%
* Wind velocity = 10-20km/ha

**Site evaluation-** the soil and vegetation must be worthy and capable of being improved;the area to be burnt should be of a size and shape that will permit burning in a day with reasonable expectation of successful burning and complete fire control.

**Site preparation-** fire lines (fire breaks, fire lanes or control lines) must be preparedbeforehand. These are strips of land devoid of fuel by scraping the land using a bulldozer blade, road grader, disc power, or manually. As a general guide, if a fire lane 3m in width will not permit fire control, prescribed burning should not be attempted.

**Management incorporating use of fire**

* Burning every 3rd or 4th year in a poorly managed grazing system is common recommendation
* A rest period is needed prior burning to allow build up of combustible material
* A post burn rest is needed to allow grasses to recover and build food reserves before being grazed determined by herbage production and rainfall distribution.
* Precautions must be taken to prevent fire from going out of control:
* Boundaries or fire breaks need to be prepared (strips of land 2 m wide on a flat land and 5-6m in sloppy areas)
* Burning should be made when people are alert (before noon)
* Participatory involvement by community members may enable a burn to proceed more smoothly.

**2. Mechanical bush control**

In some cases it might become necessary to use equipment for the removal of trees and shrubs from a rangeland. This requires heavy machinery and the following account should be given:

* Effectiveness on target species and potential damage to non target species and desirable ones
* Effect on regeneration by seed and sprouting (for species that grow under the soil)
* Erosion hazard due to cover reduction
* Site suitability and cost

There are two main approaches:

* Removal of the aerial portion of the plant only
* Removal of the entire plant

The following are the commonly practiced mechanical means of control of bush encroachment:

Simple top removal/hand slashing

* Slashing of all above ground woody stems by hand. It give good result if combined with burning
* Reducing canopy cover by shredding/chopping

**Chaining:-**Two connected tractors connected by a heavy cable or ship anchor chain to dragdown and uproot brush stands. Re sprouting could, however, exist hence this should be accompanied by other treatments like burning or spraying.

**Bulldozing:-**Clear bush and small trees and also push debris into a place for burning

**Halt breaker:-**A heavy roller which flattens and smashes bushes and small trees. It needs to befollowed by burning and reseeding.

**3. Biological control of bush encroachment**

There are two methods of biological control. The use of browsing animals (camels, goats and game animals) and the introduction of exotic insects which attack specific species of plants are biological control. However, the introduction of exotic insects is not recommended to avoid unforeseen consequences. Biological control using browsing animals can have a significant effect on bush control if the animal population is commensurate with the available browse vegetation.

There is no shortcut in finding the ideal enemy for a rangeland pest, one that keeps a weed at low densities and is relatively free of resident predators and diseases. Some of the characteristics ofan effective natural enemy are

 (1) High searching ability,

 (2) High degree of host specificity,

 (3) As great reproductive capacity as the host,

 (4) Adaptability to the host environment,

 (5) Application on land where other controls are excluded because of cost or terrain,

 (6) Permanency where the host appears annually,

 (7) Environmentally safe, and

(8) Potential for integration into a pest management program.

**Chemical control**

Herbicides (weedicides) are chemicals that kill plants or severely interrupt their normal growth process. They are an effective means for the control of noxious plants in grasslands.

They best meet requirements of an ideal herbicide:

 (1) Selective action,

(2) Economical application,

 (3) Ease in handling,

 (4) Efficacy on the target species,

(5) Nontoxicity to animals,

(6) Noncumulative and no damaging consequences in food chains and the environment.

Selection of herbicides, their concentration, application technique and time of application is important for their efficient use. Herbicidal control method has a number of advantages over other control measures. They can be used easily on steep, rocky, muddy areas, provide rapid control have low labour requirement and can be selectively applied with minimum damage to desirable plant species. Many factors should be taken into consideration while applying chemicals to control bush encroachment.

* Method of application
* Risk of contamination to neighboring cropping lands
* Cost of chemicals
* Effect on non-targeted plants and animals
* Residual effect of chemicals

**Herbicides are of following types (Valentine, 1989):**

1. Contact herbicide: A herbicide that causes localized injury and only to plant parts directly contacted.
2. Systemic or Translocated herbicide: A herbicide applied to one part of a plant but which is spread throughout the plant where effects are produced.
3. Selective herbicide: A herbicide that kills or damages a particular plant species or group of species with little or no injury to other plant species.
4. Non-selective herbicide: A herbicide that generally kills or damages all plant species to which applied.
5. Soil-active herbicide (Soil sterilant): A herbicide, which kills or damages plant when present in soil. The effect may be temporary or permanent and selective or non-selective.

The common properties of herbicides used in grasslands are given in Table below.

Table below shows Properties of herbicides used in grassland

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Herbicide** | **Group and type of** | **USES** |  |
|  |  | **herbicide** |  |  |  |
|  |  |  |  |  |
|  | 2,4-D | Phenoxy, selective, | Effective on many broad-leaved |
|  |  | translocated foliage | herbaceous plants and some shrubs. |
|  | Glyphosate | Aliphatic, | nonselective, | Used in total plant control, often |
|  | (Round up) | translocated | foliage, | applied with 2,4-D persists 1-3 |
|  |  | broad spectrum | weeks in soil. |
|  | Paraquat |  |  |  |  |
|  | (Gramoxone) | Bipyridyl,selective to non | Used as spot treatment, can be |
|  |  | selective, contact, foliage | applied just prior to range seeding, |
|  |  |  |  | has minor effect on broad leaf |
|  |  |  |  | Perennials. |
|  | Picloram | Picotininc,selective, | Effective as foliage spray or pellets |
|  | (Tordon) | translocated,foliageor | on leafy spurge, prickly pear, thistle |
|  |  | soil, non-volatile. | etc. |
|  | Triclopyr | Phenoxy- |  | Effective on broad leaf weeds and |
|  | (Garlon) | picolinic,selective, | shrubs, also effective in basal spray |
|  |  | translocated foliage | and trunk injection degraded rapidly |
|  |  | applied. |  | in soil, can be mixed with 2,4-D. |
|  | Atrazine | Triazin,selective,soil | Kills annual grasses and broad leaf |
|  |  | active herbicide. | weed seedling, providing chemical |
|  |  |  |  | fallow or range Persists for over 1 yr |
|  |  |  |  | in dry soil. |
|  | Dalapon | Aliphatic,translocated | Foliage spray on emerged aquatic |
|  | (Dowpon) | selective foliage | such as cattails and rushes, persist in |
|  |  |  |  | soil up to 2-6 weeks. |
|  | Amitrole(Weedazole | Trizole,foliage,non | Effective on thistle horsetail, cattails |
|  | and aminotriazole) | selective, translocated | poison ivy, suggested for patch |
|  |  |  |  | treatment, persists 2-4 weeks in soil. |
|  | Kerosene or Diesel | Organic compound non- | Mostly used in basal trunk spraying, |
|  | oil | selective, foliage or trunk | minimum persistence in soil |
|  |  | Applied |  |  |  |

**CHAPTER 7. RANGE RESOURCES INVENTORY AND MONITORING**

Rangeland inventory and rangeland monitoring are the processes of describing and evaluating the resources at a rangeland site. The environment is the basic determinant of the nature and productivity of rangeland eco-systems. Physical environmental factors, which include climate, topography and soil, determine the potential of rangeland to support certain types and levels of land use. Understanding of how the various environmental factors affect rangeland vegetation is crucial to successful rangeland management.

**7.1. Rangeland inventory**

An inventory is a survey of natural resources that documents the amount, kind and or location of different resource types at one point in time. An inventory is defined as the collection, assemblage, interpretation, and analysis of natural resource data for planning or other purposes. These inventories include physical structures, hydrologic features, rangeland ecological sites, animal resources, and other variables pertinent to the planning process.

**7.2. Rangeland monitoring**

**Monitoring is defined by the dictionary** as ―to watch, keep track of, or check usually for aspecial purpose. Rangeland monitoring means to make repeated measurements or observations over time to establish whether or not changes in selected resource attributes have occurred. The purpose of monitoring is to document change over time in vegetation or other rangeland resources. The emphasis on change is what distinguishes monitoring from rangeland inventories.

Rangeland resource inventory studies aims at assess resource use and availability **at one point in** **time**. However, the determination of trend relationships is often the chief concerning in rangeresource evaluation studies. Due to this, monitoring of rangeland resources has become important part of range management on both private and public lands.

This entails identifying and documenting changes in the resource overtime providing information to evaluate management practices in relation to natural influences such as climate. There are many very good reasons to monitor range lands, these include improving production, maintain the best mix of plant species, reduce erosion, maintain the health and function of rangelands, improve water quality, maintain resource sustainability, demonstrate good stewardship, or because a government agency requires it. All of these are good reasons. But we need to monitor to help us make better decisions in managing our natural resources for the future. Monitoring allows managers to identify the resources they have available, and the potential sustainability of these resources in the future. Monitoring also teaches a person who looks carefully at the land will see new relationships among plants, soil, water, and animals.

**Selection of Vegetation attributes**

Rangeland inventory and monitoring programs have usually focused on describing [vegetation](http://rangelandswest.org/az/inventorymonitoring/vegetation.html) [attributes,](http://rangelandswest.org/az/inventorymonitoring/vegetation.html) although soil characteristics are assuming greater importance in resources. Vegetation attributes are quantitative features or characteristics of vegetation that describe how many, how much, or what kinds of plant species are present. Vegetation attributes commonly measured in rangeland inventory and monitoring programs include: Species Composition, Frequency, Production, Cover, Structure and density.

1. **Species or plant name:-**plant names are important since plant species often have differentenvironmental requirements, respond differently to land use pressures and have inherently different qualities.
2. [**Density**:](http://rangelandswest.org/az/inventorymonitoring/density.html) **-** is the number of individuals per unit area or it is the average area per individual.Two general approaches can be adopted to determine [density.](http://rangelandswest.org/az/inventorymonitoring/density.html) With the first approach, density is directly determined by counting plants within a defined sample unit, whereas the second approach is a [plot less](http://rangelandswest.org/az/inventorymonitoring/plotless.html) method based on measuring the distance or spacing between plants. It may provide useful inventory information for large perennial species, particularly trees and shrubs.
3. [**Frequency**](http://rangelandswest.org/az/inventorymonitoring/frequency.html) –is the number of times a given event occurs. In many studies, the termfrequency indicates the number of samples in which a species occurs. This is expressed as the proportion of the total number of samples taken that contains the species in question. Thus if a species were found in 7 out of 10 samples taken, it would have a frequency of 7/10, or 0.7. Relative frequency of a species is the frequency of that species divided by the sum of the frequencies of all species in the community.

[**Cover:**](http://rangelandswest.org/az/inventorymonitoring/cover.html)**–**is Area of vegetation, or other surface features, in relation to the area of ground.Cover can be expressed in absolute terms, basal area/area of ground, or as a percentage.

**Ground cover is** - Percent of the soil surface covered by some type of protection (litter, rocks, vegetation, etc).

**Canopy cover** - is a vertical projection of the perimeter of a plant canopy to the ground.[**Basal cover**-](http://rangelandswest.org/az/inventorymonitoring/basalcover.html) **is** generally considered a more stable measure than[canopy cover](http://rangelandswest.org/az/inventorymonitoring/canopycover.html)toidentifyherbaceous vegetation change, since it is less influenced by weather fluctuations, time of year, and immediate grazing history.

[**Species Composition**](http://rangelandswest.org/az/inventorymonitoring/composition.html) **–** refers to the contribution of each plant species to the vegetation.Botanical composition is another term used to describe species composition. Species composition is generally expressed as a **percent**, so that all species components add up to 100%. The dry-weight rank method is specifically designed to determine [species composition](http://rangelandswest.org/az/inventorymonitoring/composition.html) by providing a measure of the relative contribution of various species to the total [biomass](http://rangelandswest.org/az/inventorymonitoring/biomass.html) (based on [dry matter content)](http://rangelandswest.org/az/inventorymonitoring/drymatter.html) for a site. Dry-weight rank results are expressed only as percentage values, and do not quantify the actual biomass for each species. For example, dry-weight rank sampling may indicate that black grama *(Bouteloua eriopoda*) makes up 11% of herbaceous biomass and burroweed (Isocoma tenuisectus) makes up another 43% of the total biomass, but we do not have the information to convert these values to quantify the actual biomass (kg/ha or lb/acre) for either species. However, this problem can be circumvented by also determining the total biomass for the site, which is then proportioned to various species according to the percentage values derived from the dry-weight rank method.

1. **Species diversity**: this is an expression of community structure. It consists of two relatedcomponents:
2. *Species richness*: a count of the number of plant species in a quadrat or area.
3. Evenness: relative abundance of species within the sample or area.

**Diversity of species** is thus measured by recording the number of species (richness) andrelative abundance (evenness). A community is said to have a high species diversity if many equally or nearly equal abundant species are present.

**Biomass** (yield' or 'production')**: -** is a commonly measured vegetation[**attribute**](http://rangelandswest.org/az/inventorymonitoring/attributes.html) thatrefersto the weight of plant material within a given area. [Biomass](http://rangelandswest.org/az/inventorymonitoring/biomass.html) is a general term that encompasses many special [attributes.](http://rangelandswest.org/az/inventorymonitoring/attributes.html) For example, inventory or monitoring programs focusing on grazing applications may only want to estimate available [forage,](http://rangelandswest.org/az/inventorymonitoring/forage.html) whereas those addressing ecological perspectives may need to estimate [productivity.](http://rangelandswest.org/az/inventorymonitoring/productivity.html) In some instances, the objectives of the [sampling](http://rangelandswest.org/az/inventorymonitoring/sampling.html) program could be tied to [current year's production,](http://rangelandswest.org/az/inventorymonitoring/growth.html) while at other times an estimate of dead or alive biomass is most relevant. The decision of exactly what to measure depends on sampling objectives and availability of resources, and should be clearly supported by [ground rules.](http://rangelandswest.org/az/inventorymonitoring/rules.html)

**CHAPTER 8. PASTORALISM AND RANGE MANAGEMENT**

**8.1. Concepts of pastoralism and some terminologies**

**Pastoralism**

* depending primarily on herds of domesticated animals
* pastoralists move their herds to pasture areas, rather than bringing food to them
* typically, some or all of the pastoralists move with the herds, thus, pastoralists are not sedentary

**Sedentary**: having one permanent place of residence, year-round, that is, not mobile at all

**Semi-sedentary**: various partially settled schemes

* stay in a settlement for years, then move on and establish a new one
* usually seasonal
* as in having a permanent winter village, from which people disperse in the summer to temporary hunting and gathering camps
* have several established residences, and shift between them

**Nomadic**: having no permanent place of residence, always living in temporary camps

**Transhumant** (practicing transhumance): moving through a set seasonal round

* may have fixed settlements that are revisited every year in a certain season
* in which case they are semi-sedentary and transhumant
* or may cycle through the same general areas each year, but not to established settlements in each area
* in which case they are nomadic and transhumant (transhumant nomads)

**Purely nomadic**: no set route or stopping places at all

* always on the move, not in any routine pattern
* this extreme form of nomadism is rare or maybe even non-existent
* it may really be just a theoretical concept that serves to define a range of variation from strict transhumance to pure nomadism

**Rangeland utilization systems**

The principal system of rangeland utilization is expected to be Pastoralism in its different forms. Pastoralists depend for more than 50% of their income on livestock. Household gross revenue (the total value of marketed production and estimated value of subsistence production consumed within the household) comes from livestock and livestock related activities.

**Pastoral systems could be;**

1. **Nomadic Pastoralism – which** involves extensive movement without the necessity to return back to a “base” every year and does not include cultivation
2. **Transhumant Pastoralism** – which involves movement but between definite seasonal bases every year. It may include a non-sedentary, opportunistic form of cultivation.
3. **Semi-** **transhumant Pastoralism** –where only part of the family and/or livestock (strong adult male people, adult male animals, adult barren females and few lactating animals to provide milk for the migrating people) is seasonally mobile, and the rest (Children and mothers, young animals) is sedentary in one of the seasonal bases practicing cultivation.

However, pastoral socio-economic systems can further be distinguished by combinations of other activities with those of herding. **Such combined systems include the following;**

**Agro-Pastoralism-** this is cultivation and herding system where families and livestock aresedentary. Agro-pastoralists drive 50% of their income from sedentary cultivation.

**Sylvo-pastoralism**- this is a tree growing and herding system.

**Agro-sylvo Pastoralism** - includes cultivation, tree growing and herding.

**Range Management**

**What is rangeland management?**

* The careful use and management of rangeland resources (plants, animals, soil, and water) to meet the needs and desires of society
* Range Management: is the manipulation of rangeland components to obtain the optimum combination of goods and services for society on sustained bases.

**Range management:** The science of maintaining maximum-range forage production without jeopardy to other resources or uses of the land. Grazing land management as applied to native and seeded rangelands and practical experience for two purposes:

(1) protection, improvement, and continued welfare of the basic resources, which in many situations include soils, vegetation, endangered plants and animals, wilderness, water, and historical sites; and

(2) Optimum production of goods and services incombinations needed by society.

Management of rangeland requires selection of alternative techniques for optimum production of goods and services with no resource damage

**Objectives of range management**

The central objective of range management is sustainable production of domestic and wild animals in a manner that protects the land.

The specific objectives of range management are listed below.

* Protect, improve and promote the continued welfare of the range soils, vegetation and animals.
* Optimum production of animal products (meat, milk, hides, wool/hair), wildlife and water (from watershed).
* Provide recreational sites.
* Conserve biodiversity of plant and animal genetic resources.

**Rangeland degradation and the role of range management**

Confusion arises from the use of the terms **degradation** and **desertification** either interchangeably or in a completely different ways.

**Desertification** is the diminution or destruction of the biological potential of land that can lead ultimately to desert like condition.

**Land degradation** is a reduction in the long term soil productivity either **under climatic or man** made changes that results in the long term decrease in **biomass** and **vegetation cover** of perennials natural vegetation.

Rangeland degradation is an effectively permanent decline in the rate at which land yields livestock products under a given system of management.

**2. Causes range land degradation**

In the dry land range lands where pastoral systems are practiced the alleged causes of range land degradation has been overgrazing due to

* The pastoralists’ tradition of over stocking rangelands and sub optimal or mismanagement of resources.
* Increasing human population,
* The inevitable marginalization of fragile ecosystems,
* Urbanization
* Large irrigation schemes for generating hard currency,
* Faulty development projects (water development, market development, road construction etc), inappropriate pastoral policies, etc.

Conventional range management depends on vegetation attributes as indicators of range degradation.

These vegetation attributes include cover, species (botanical) composition, biomass, density etc.

Large fluctuations in species composition, plant biomass, and cover are characteristics of arid and semi-arid range lands subject to erratic rainfall pattern with an ability to return quickly in the absence of these disturbances.

Since the reliability of vegetation changes as indicators of irreversible range land degradation in arid and semi-arid areas is questionable, other potential biological and physical indicators of range degradation have been proposed

Table 3. Biophysical indicators of rangeland degradation

|  |  |
| --- | --- |
| Attributes | Symptoms |
| Soil | Decreased fertilityDecreased water holding capacityDecreased infiltrationDecreased top soil depthHigh rates of erosion |
| Vegetation | Changes in productivity over time unrelated to rainfall patternChanges in coverChanges in species composition of use to animalsShifts between vegetation states to a low fodder value (e.g. palatable to invader species) |

In addition to the above stated biophysical indicators of rangeland degradation there are also other indirectly related variables, which serve as indicators. Some of these variables may be directly related to the environment and /or socio economic phenomena and include the following:

* Precipitation (amount, distribution, intensity)
* Resilience (the ability of land to return to original status after being relieved from a temporary shock)
* Number of animals present
* Runoff from water shed
* Prices of agricultural commodities such as grains and livestock
* Human mass migration
* People’s opinions and perceptions about the changes that occurred on their environment.

**8.2. Pastoralism and nomadism**

**Pastoral systems**

Williams (1981) has listed and described four systems of pastoralism (i.e., grazing management systems) used throughout the world: nomadism, semi-sedentary, transhumance, and sedentary. **Nomadism**. It is characterized by no main home base; herds, flocks, people, and belongings move together, following the rains and seasonal availability of forage but within no set annual pattern; and the people and livestock are found only temporarily in rural centers for rest or grazing livestock on crop residues.

**Semi-sedentary** differs in utilizing a built village or common home base where the women and children permanently reside, but from which the men and boys with their herds are absent for extended periods.

**Transhumance** is associated with cyclical, annual movement of livestock between distinctive seasonal ranges; movable tents or mobile homes are utilized by shepherds or herders when accompanying the livestock. This system is found over many parts of the world.

**8.3. Pastolism in Ethiopia**

* Pastoralist is one of the oldest socio-economic systems in Ethiopia in which husbandry in open grazing areas represents the major means of subsistence for the pastoralist.
* At present, the vulnerability of the pastoral community to droughts has reached a serious stage claiming the lives of both humans and livestock every four to five years.
* Any development interventions during drought in line with feed (others like: water, health and marker) depend on appropriate polices of national government, local administration, donors, NGOs, and development agencies.
* Interventions can be effective only if the policy environment is right.
* Efforts to develop feed, for example will cope with the fluctuation in forage yield resulting from climate variability. In line with this, training of community animal health workers will allow them to treat well fed animals; also efforts to build market infrastructure, will succeed only if policies promote livestock trade.

**Chapter 9. GIS and Remote sensing as a tool for rangeland resources assessment and monitoring**