Review Article

iMedPub Journals
www.imedpub.com

Journal of Plant Sciences and Agricultural Research

2019
Vol.3 No.1:19

Factors Affecting the Productivity of Rangelands

Mebrate Getabalew[1] and Tewodros Alemneh[2*]

[1]College of Agricultural and Natural Resources Science, Department of Animal Science, Debre Berhan University, Ethiopia

[2]Woreta City Office of Agriculture and Environmental Protection, South Gondar Zone, Amhara Regional State, Ethiopia

[*]**Corresponding author**: Tewodros Alemneh, Woreta City Office of Agriculture and Environmental Protection, South Gondar Zone, Amhara Regional State, Ethiopia, Tel: 251 9 20 49 98 20; E-mail: tedyshow@gmail.com

Received date: August 10, 2019; **Accepted date**: September 12, 2019; **Published date**: October 25, 2019

Citation: Getabalew M, Alemneh T (2019) Factors Affecting the Productivity of Rangelands. J Plant Sci Agri Res Vol.3 No.1:19.

Abstract

Rangelands are any extensive areas of land that are occupied by native herbaceous or shrubby vegetation which are grazed by domestic or wild herbivores. They are geographical regions dominated by grass and grass-like species with or without scattered woody plants, occupying about 40%-50% of the land area of the Earth. It is thought that rangelands are home both to significant concentrations of large mammals and plants with a high value in both leisure and scientific terms and to human populations that have historically been excluded and marginalized, pastoralists and hunter-gatherers. Rangelands are characterized by low and/or erratic precipitation, poor drainage, rough topography, and often have low soil fertility. Rangelands have an important role in ecological stabilization and the terrestrial carbon cycle in arid and semi-arid regions of the world. Management of rangelands ranges from nomadic pastoralism to subsistence farming, to commercial ranching. There is widespread agreement that climatic conditions are changing and such changes will likely continue, becoming more apparent in coming decades. Uncertainty poses a problem for land and resource managers as they seek to adapt to changes and mitigate the adverse effects of climate change. We argue, first, that a focus on vulnerability to climate change and its effect is more useful for managers than a focus on the probability and consequences of a particular change. Secondly, we argue that monitoring, based on systematically considered and selected indicators, provides managers information they need to adaptively manage for sustainability. As a result, this review updates information on the influential factors that commonly affect rangelands worldwide.

Keywords: Rangeland; Carbon cycle; Climate change; Vulnerability; Factors

Introduction

Rangeland is an uncultivated land that is suitable for grazing and browsing animals. Rangeland is one of the major types of land in the world (other types are: forest, desert, farmland, pasture, and urban/industrial). Rangelands are the principal source of forage for livestock, and they also provide habitat for a great variety of native plants and animals. Rangelands are also used by people for recreational purposes. Some plant species of rangelands are used in landscaping, and as sources of industrial chemicals, pharmaceuticals, and charcoal. Generally, rangeland is not fertilized, seeded, irrigated, or harvested with machines. Rangelands differ in this respect from pasturelands, which require periodic cultivation to maintain introduced (non-native) species of forage plants. Pasturelands may also need irrigation or fertilization, and they are usually fenced. Rangelands were originally open, natural spaces, but much of their area has now been fenced to accommodate human uses, particularly livestock grazing. In addition, livestock grazing often utilizes rotation systems that require partitioning. Rangelands were distinguished at the turn of the century by their native vegetation. Today, however, many rangelands support stands of introduced forage species that do not require cultivation [1].

Rangelands cover at least 10 million km^2 of the earth's land surface and range from desert to mountainous or highland regions. They are characterized by low and highly variable precipitation, unpredictable rainfall patterns and unsuitable conditions for cultivation. Historically, these rangelands have provided great ecosystem functions and services, supported wildlife, and have long been places for rangeland users including pastoralists and their livestock. Accordingly, rangeland users have been able to more freely use the services that these ecosystems provide and adapt to changes in ways that have improved their livelihoods [2].

However, during the second half of the 20th century in many countries, new changes and challenges emerged, which, disrupted the well-adapted strategies and demised the traditional systems of rangeland management. Consequently, rangeland degradation followed by livelihoods' vulnerability of rangeland users affects Sustainable Rangeland Management

(SRM) [3]. Rangelands which recently support around 200 million pastoralists living in close association with about 960 million ruminant livestock are under serious threats and jeopardizing their services and benefits [4].

Climate change is altering the global hydrologic cycle and is expected to have substantial and diverse effects on precipitation patterns in different regions. Predictions include increased intensity of precipitation events worldwide, increased wet days at high latitudes, and increased drought across many mid-latitude continental interiors. However, there is still considerable uncertainty regarding rates of changes in temperature and the direction of precipitation responses in many regions [5]. This uncertainty greatly complicates our ability to develop specific management practices to cope up and adapt. In addition to climate change, rising atmospheric CO_2 concentration, which has been steadily occurring since industrialization, has two important direct effects on plant physiology. Increased CO_2 tends to increase photosynthesis in many plant species. It can also reduce transpiration water loss. These direct responses to CO_2 may actually enhance plant productivity and water use efficiency, although plant species differ in their sensitivity to CO_2; and some undesirable plants may be preferentially benefited [6].

Rangeland managers have always lived with climate variability. However, the changes being observed now and predicted over future decades present a new challenge in that they are unidirectional and the rate of change is expected to accelerate beyond what modern humans have experienced. Thus, climate change may manifest itself in unique ways at local and regional levels [7]. Having an introduction in this way, the objective of this review is, therefore, to discuss the factors that affect the productivity of rangelands.

Types of Rangelands

Rangelands support plant communities that are dominated by species of perennial grasses, grass-like plants (or graminoids), forbs (non-graminoid, dicotyledonous plants), and shrubs. There are five basic types of rangelands worldwide: Natural grassland, Desert shrubland, Savanna woodland, Forest, and Tundra. Grasslands do not have shrubs or trees growing on them. Desert shrublands are the most extensive and driest of the rangelands. Savanna woodlands are a transition between grasslands and forests and contain herbaceous plants interspersed among scattered, low-growing shrubs and trees. Forests contain taller trees growing closer together than in savanna. Tundra areas are treeless, level plains in the Arctic or at high elevations of mountains [1,8]

North American rangelands consist of: (1) the prairie grasslands of the Midwestern United States and extending into Canada, as well as parts of California and the northwestern states; (2) cold desert rangeland in the Great Basin of the United States, and hot desert (Mojave, Sonoran, and Chihuahuan) of the southwestern United States and northern Mexico; (3) open woodlands from Washington state to Chihuahua, Mexico, and in the Rocky and Sierra-Cascade Mountains; (4) forests (western and northern coniferous, southern pine, and eastern deciduous); and (5) alpine tundra (mostly in Alaska, Colorado, and western Canada) and arctic tundra (in Alaska and northern Canada). There are more than 283 million hectares of natural range ecosystems in the United States. However, much of the United States prairie grasslands have been converted to agricultural land-use. In addition, excessive grazing and fire suppression have allowed the invasion of prairie by species of woody plants, such as mesquite, in some regions [1,9].

Factors Affecting the Productivity of Rangelands

Climate change

Climatic factors like temperature, humidity, precipitation, light intensity, and altitude may control the nutritive value of plants. Although plants are dependent upon the soil for their mineral nutrients, climatic factors affect respiration, assimilation, photosynthesis, and metabolism to the extent that the mineral and organic matter content of plants may be strongly modified by climatic factors even though grown on the same soil.

Over the past few decades, average temperatures have increased in this region, with fewer cold days, more hot days, and increased precipitation over much of the world. Extreme events such as drought, heatwaves, and intense precipitation events are predicted to become more common. Temperature is predicted to continue to rise, with increases being greater in the northern reaches and summer temperatures expected to increase more than winter temperatures for the southern and central Great Plains [5,10].

Climate change and rangeland disturbances influenced by climate change will affect the entire suite of ecosystem services that rangelands provide, including forage for wildlife and livestock production, fishing, hunting, and other forms of recreation, clean water, and air, and aesthetically pleasing landscapes. They will do so by directly varying temperature and precipitation patterns and indirectly affecting disturbances such as fire, insects, invasive species, erosion, and drought. Also affected are core ecological processes of soil formation, energy flow, nutrient cycling, and biodiversity that maintain properly functioning ecosystems, and which are collectively necessary for humans to exist [11].

Edaphic influences

The edaphic factor includes the physical, chemical, and biological properties of soil that result from biologic and geologic phenomena or anthropogenic activities. Discontinuities in the edaphic factor contribute to the intriguing patterns of diversity we see in the biotic world. Chemical and physical features of soil greatly influence the ecology and evolution of plants and their associated biota [12].

The properties of soils exert almost unlimited influence upon the nutrient content of plants. A different report concluded that the mineral composition within a species was determined primarily by soil. It has long been known that plants are grown on soils rich in certain nutrients usually are also rich in these nutrients. Physical properties of soil such as texture and porosity affect the nutritive quality of forage more or less indirectly. Poorly aerated soils greatly limit or decrease the absorption of essential elements, especially phosphorus. Soils rich in biotic life show enhanced aeration and fertility. Chemical properties of the soil may determine the nutrients that plants are able to absorb. For example, phosphorus is most available between pH 6 and pH 7. Phosphorus in soils of low pH reacts chemically with hydrous oxides of iron, aluminum, and magnesium to form insoluble compounds that are unavailable to plants. At pH 7 and above, phosphorus again becomes insoluble as calcium phosphate [13].

Rangeland managers

Ranchers and other private and public land managers should make the maintenance of rangeland health and productive capacity a business goal as reinforced by findings alluded to above in, particularly at the landscape level. Ecosystems are more susceptible to droughts, invasive species outbreaks, wildfire, and other episodic events when they lack diversity and resilience. Identifying and monitoring such vulnerabilities and focusing adaptive management on those vulnerabilities is one way for managers to respond to changing conditions in spite of uncertainty [14].

Land managers should learn as much as possible about how their ecosystems may respond to climate change. Answers to some basic questions will allow them to anticipate responses to change and incorporate that knowledge into their management planning. Management for ecosystem services requires landowners and managers to incorporate all the above information into a plan based on a systematic framework to identify and establish a system of indicators for monitoring the ecosystem processes, goods, and services produced by the land, weather, and major risk factors associated with climate change [14].

Proper rangeland management includes good stewardship of the rangeland biological components to preserve soil health and soil conservation. Certain management practices can also contribute to a host of soil-related problems ultimately leading to a general reduction in the land's ability to sustain healthy rangeland systems. Many of these problems can be avoided by the proper management of the biological component of the range. While the concept of managing healthy rangeland may seem simple and straight forward, different definitions of what constitutes healthy rangeland result in divergent management approaches [15].

Wildlife

Many rangelands are also subject to grazing by wildlife. Therefore, consideration must be given to wildlife as a factor in rangeland management, especially regarding stocking rates, to ensure the conservation of rangeland productivity. Because non-game wildlife species impact forage resources, stocking rates should be adapted to occurring wildlife density. Conservative strategies to improve rangeland conditions and wildlife habitat have attracted increasing interest as society has changed [16].

In the context of rangeland and wildlife, game ranching is an increasingly important operation. This includes bison production, which is becoming more and more popular in the United States and Canada. In South Africa, numerous wildlife ranches have been established since the 1960s because they offer higher incomes than livestock farming. One reason for the increase of game ranching, apart from economic considerations, is the fact that native animals are better adapted to local conditions (foraging, water, climate), particularly in areas with extreme climate conditions [16].

Livestock producers

On rangeland, good livestock producers stock their pastures to leave sufficient foliage on the good forage plants in order to maintain the physiological health of the desirable plants. The ungrazed portion of the plants feeds the roots on the perennial grasses preparing them for dormancy and the start of the next growing season and/or allows the production of seeds on the perennials and annuals. The desirable grasses and forbs in rangeland are called “decreasers” because their abundance and production will decrease under too intense grazing pressuring [17].

Conversely, undesirable forage plants and noxious weeds will increase in abundance, competing with the “decreasers” and further reducing the carrying capacity of the pastures. Grasshopper outbreaks complicate rangeland management by increasing grazing pressure tremendously. Just 14 adult M. sanguinipes per square meter equates to approximately 50 kg of grasshopper biomass per hectare. Grasshoppers can eat the equivalent of their body weight in forage plants daily. In addition to what they consume, they can make forage unavailable to livestock by clipping and dropping leaves to the ground [18]. A typical cow weighing 454 kg stocked at 1 per 8 ha for the Western grazing season is approximately 56.75 kg of biomass per hectare and would consume between 2.5% and 3% of her body weight daily in dry weight forage [19]. Grasshoppers easily out-compete with livestock for forage due to their small mouths that allow them to eat forage too short for larger animals to graze upon. The long-term consequences of grasshopper infestations can be severe, with the rangeland permanently degraded, losing desirable perennial plant cover [20]. The increased bare ground caused by the decline in plant cover is vulnerable to wind and water erosion and the invasion of noxious weeds [18].

Impact of grazing on ecosystem

Grazing animals have several direct and indirect impacts that can improve or degrade rangelands depending on the timing and intensity of grazing. Foraging animals affect rangelands by removing vegetation, roughing up and compacting soil through hoof action, and depositing minerals and nutrients in the form of urine, feces, or the animal’s carcass. Appropriate and well-managed grazing can favor desirable plants, improve habitat for wildlife, reduce weed invasion, reseed areas for restoration, reduce mulch accumulation, increase soil organic matter, and reduce fuel loads that promote wildfire. Overgrazing and prolonged poorly managed grazing can remove desirable plants, decrease water infiltration into the soil, increase soil erosion, reduce water quality, increase weed invasion, and alter the plant community composition to a less desirable state. Therefore, the impacts of grazing depend on when and how it occurs.

What is Overgrazing?: Many people are concerned that excessive grazing by livestock or wildlife creates rangelands that are “overgrazed.” Overgrazing is defined as repeated heavy grazing results in deterioration of the plant community. Caution must be taken when declaring a range as “overgrazed” because it is difficult to truly assessing whether the land is “overgrazed.” Pastures can be heavily grazed but that may not lead to land degradation. In fact, some grazing systems designed to improve and restore rangelands are accomplished by grazing a pasture very heavily once and then giving the pasture several years of rest (e.g., Rest-Rotation or Management-Intensive Grazing). True overgrazing is when continued grazing exceeds the recovery capacity of the plant community and causes a shift in plant composition and soil conditions away from the desired community. Overgrazing normally can be attributed to heavy, repeated grazing over several years [15].

Overgrazed rangeland is often characterized by an increase in less palatable plants, increased soil erosion, an increase in weedy species that thrive under disturbance, and decreased the production of important forage plants. Rangeland deterioration results from animals continually and closely eating the most palatable plants until those plants are stressed so much they fail to reproduce and/or die. Overgrazing can also correspond with soil compaction or disruption of soil crusts resulting in decreased water infiltration and increased erosion. Due to the complex nature of animal preferences, highly desirable areas in a pasture may experience overgrazing while other regions experience little or no use [15].

Range plants evolved to withstand grazing and can withstand a heavy grazing event if done in the right season and if plants are given enough time to recover after grazing. Most rangeland grasses and forbs can have 40%-50% of their leaves and stem removed every year and still remain healthy and productive. In general, light use is considered less than 40%, moderate 40%-65%, and heavy greater than 65% of biomass removed [15].

Environmental factors

Environmental factors affect range plant growth. The three most ecologically important environmental factors affecting rangeland plant growth are light, temperature, and water (precipitation). Plant growth and development are controlled by internal regulators that are modified according to environmental conditions. A research project was conducted to describe the three most important environmental factors in western North Dakota and to identify some of the conditions and variables that limit range plant growth. Rangeland managers should consider these factors during the development of long-term management strategies [21].

Light is the most important environmental factor affecting plant growth. Light is necessary for photosynthesis, and changes in day length (photoperiod) regulate the phenological development of rangeland plants. Changes in the day length function as the timer or trigger that activates or stops physiological processes, initiating growth and flowering and that starts the process of hardening for resistance to low temperatures in fall and winter. The tilt of the earth's axis in conjunction with the earth's annual revolution around the sun produces the seasons and changes the length of daylight in temperate zones [21].

Water (precipitation) is essential for all plants and is an integral part of living systems. Water is ecologically important because it is a major force in shaping climatic patterns and biochemically important because it is a necessary component in physiological processes. Plant water stress limits growth. Water stress can vary in degree from a small decrease in water potential to the lethal limit of desiccation. The long-term (113 years) annual precipitation for the area of Dickinson, North Dakota, is 16.03 inches (407.20 mm). The growing season precipitation is 13.56 inches (344.34 mm), 84.59% of the annual precipitation. June has the greatest monthly precipitation, at 3.56 inches (90.35 mm) [21].

Drought

Drought years occurred during 12.4% of the past 113 years, and 15.0% of the growing seasons were drought growing seasons. The 113-year period (1892 to 2004) contained a total of 678 growing season months. Water deficiency conditions occurred during 220 of these, a finding indicating that during 32.45% of the growing season months, or for an average of 2.0 months during every 6-month growing season, range plants were under water stress and therefore limited in growth and herbage biomass accumulation. Water deficiency occurred in May and June 14.2% and 9.7% of the time, respectively. Water deficiency conditions occurred in July less than 40% of the time. Water deficiency conditions occurred in August, September, and October more than 50% of the time: 51.3% of the time in August, 50.4% of the time in September, and 47.8% of the time in October. Water deficiency conditions lasting a month or more cause plants to experience water stress severe enough to reduce herbage production. These levels of water stress are a major factor limiting the quantity and quality of plant growth in western North Dakota and can limit livestock production if not considered during the development and implementation of long-term grazing management strategies [21].

Rangeland Management

The first principles of scientific range management were established by research in North America during the 1890s, and by grazing system experiments in the early 1900s. Variations of many of these practices, such as grazing rotations, had been used by pastoral herders in Asia and Africa for centuries.

Grasses of the semi-arid plains provide excellent winter forage for livestock. Unlike their eastern counterparts, which tend to fall to the ground in winter and rot, prairie grasses cure while standing and do not have to be harvested, baled, or stored for winter use. However, if they are grazed intensively throughout the summer and autumn, prairie grasses cannot produce an adequate crop of winter forage [1,22].

Good rangeland management recognizes that perennial grasses must have sufficient time for their aboveground biomass to regenerate after grazing; otherwise, the plants become overgrazed, and may not survive. A healthy population of native grasses helps to prevent invasion by non-native plants, some of which are unpalatable or even poisonous to livestock. Severe overgrazing removes too many plants of all types from an area, causing a loss of soil moisture and fertility, and increasing erosion. Range managers have learned that for the long-term health of rangelands, they cannot overstock or overgraze them with cattle or other livestock. In spite of this knowledge, excessive use of rangelands remains an important problem in most parts of the world, including North America [1,22].

Conclusion

Rangelands are open areas of land that are used for farming or hunting. Rangelands are a roam and grazing area for domestic livestock or wild animals. Rangelands are distinguished from pasture lands by the fact that they maintain native vegetation rather than what has been established by humans. Rangelands include many different climates and contain land that cannot be grazed. A wide variety of factors, such as climate change, edaphic influences, wildlife, grazing, drought, environmental factors (light, water or precipitation), the effect of rangeland managers and livestock producers are most likely affecting rangelands worldwide. Therefore, modern range management utilizes the concept of multiple-use, which requires that all the resources of rangeland be managed simultaneously, using constant monitoring and adjustments to provide a mix of material products and intangible assets that best satisfy the needs of both landowners and the general public.

Acknowledgment

Authors' deepest gratitude forwarded to Debre Berhan University Staffs, Librarians, and the Community for their material and logistic supports.

Conflicting of Interests

Authors declare that there are no conflicting interests in the publication of this article.

References

1. https://science.jrank.org/pages/5731/Rangeland.html
2. Boone RB, Galvin KA, BurnSilver SB, Thornton PK, Ojima DS, et al. (2011) Using coupled simulation models to link pastoral decision making and ecosystem services. Ecology and Society 16: 6.
3. Khedri GH, Azadi H, Witlox F (2015) Exploring appropriate livelihood alternatives for sustainable rangeland management. Rangeland J 37: 345-356.
4. Secretariat of the Convention on Biological Diversity (SCBD) (2010) Pastoralism, nature conservation and development: A good practice guide. Montreal.
5. Christensen JH, Hewitson B, Busuloc A, Chen X AG, Held I, et al. (2007) Regional Climate Projections. In: Solomon S, Qin D, Manning M, Marquis M, Averyt K, Tignor MMB, Miller J, LeRoy H, Chan Z (EDS) Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp: 847-940.
6. Morgan JA, Milchunas DG, LeCain DR, West MS, Mosier A (2007) Carbon dioxide enrichment alters plant community structure and accelerates shrub growth in the shortgrass steppe. P Natl Acad Sci 104: 14724-14729.
7. Williams JW, Jackson ST (2007) Novel climates, no-analog communities, and ecological surprises. Front Ecol Environ 5: 475-482.
8. National Research Council (1994) Rangeland health: New methods to classify, inventory, and monitor rangelands. Washington, DC: National Academy Press, pp: 1-23.
9. Holechek JL (1993) Policy changes on federal rangelands: A perspective. Journal of Soil and Water Conservation 48: 166-174.
10. Karl TR Melillo JM, Peterson TC (EDS) (2009) Global climate change impacts in the United States. Cambridge University Press, New York, New York, p: 188.
11. Havstad KM, Peters DPC, Skaggs R, Brown J, Bestelmeyer B, et al. (2007) Ecological services to and from rangelands of the United States. Ecolog Econ 61: 261-268.
12. Rajakaruna N, Boyd R (2008). Edaphic Factor. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/edaphic-factors
13. Zhang X, Yang X, Li Y, He X, Lv G, et al. (2018) Influence of edaphic factors on plant distribution and diversity in the arid area of Xinjiang, Northwest China. Arid Land Research and Management 32: 38-56.
14. Ritten JP, Bastian CT, Frasier (2010) Economically optimal stocking rates: A bio economic model. Rangeland Ecol Manage 63: 407-414.
15. Godfrey KR (2010) Factors affecting the level of commercialization among cattle keepers in the pastoral areas of Uganda.
16. Holechek JL, Pieper RD, Herbel CH (2004) Range management: principles and practices. Prentice Hall, New Jersey, p: 607.
17. Cherni JA, Dynerb I, Henaoc F, Jaramillod P, Smithe R, et al. (2007) Energy supply for sustainable rural livelihoods. A multi-criteria decision-support system. Energy Policy 35: 1493-1504.

18. Onsager JA, Hewitt GB (1982) Rangeland grasshoppers: Average longevity and daily rate of mortality among six species in nature. Environ. Entomol II: 127-133.

19. Owens MK, Lyons R (2001) Evaporation and interception water loss from juniper communities on the Edwards Aquifer Recharge area-final report: Uvalde Research and Experiment Center. Available at http://uvalde.tamu.edu/pdf/2002/028-interceptbl.pdf. Accessed on November 12, 2003.

20. Pfadt RE (2002) A field guide to common western grasshoppers. 3rd ed. Wyoming Agricultural Experiment Station Bulletin 912: 1-288.

21. Manske LL (2005) Environmental factors to consider during planning of management for range plants in the Dickinson, North Dakota, region, 1892-2004.NDSU Dickinson Research Extension Center. Range Research Report DREC 05-1018h. Dickinson, ND. 37.

22. Hodgson J, Illius AW (1998) The ecology and management of grazing systems. 2nd CABI Publications, pp: 1-67.