International Journal of Ecology and Ecosolution
Vol. 7(2), pp. 16-22, September 2020
ISSN: 2437-1327
Review

Effect of rangeland vegetation cover on climate change mitigation

Mebrate Getabalew[1], Tewodros Alemneh[2]* and Derbie Zewdie[1]

[1]Department of Animal Sciences, College of Agricultural and Natural Resources Sciences, Debre Berhan University, Ethiopia.
[2]Woreta City Office of Agriculture and Environmental Protection, South Gondar Zone, Amhara National Regional State, Ethiopia.

Accepted 24 August, 2020

ABSTRACT

Vegetation plays a key role in the global climate system via modification of the water and energy balance. Its coupling to climate is therefore important, particularly in the tropics where severe climate change impacts are expected. Consequently, understanding vegetation dynamics and response to present and projected climatic conditions for various land cover types is vital. The climate exerts the dominant control on the spatial distribution of the major vegetation types on a global scale. In turn, vegetation cover affects climate via alteration of the physical characteristics of the land surface like atmospheric gas composition, for example, CO_2 and CH_4 (biogeochemical effects). In general, the climate models agree that tropical deforestation exerts a net regional warming while an effect on extra tropical regions is more uncertain. When we see the Sahara region, several models are able to simulate “green Sahara” phenomenon during the mid-Holocene. Some models reveal multiple steady states in the region due to a strong interaction between vegetation and monsoon precipitation. Sensitivity simulations show that some expansion of vegetation cover into the Sahara is possible under CO_2-induced climate changes. Rangelands play an important role in mitigating the negative effects of climate change by reducing wind speed, temperature and store the organic carbon (carbon sequestration). They also protect the soil against wind and water erosion and sand dunes. This implies that vegetation cover and climate are directly interrelated. Hence, this review was undertaken to assess the effects of vegetation cover or rangeland on climate change mitigation.

Keywords: Climate change, CH_4, CO_2, mitigation, vegetation cover, rangeland.

*Corresponding author. E-mail: tedyshow@gmail.com. Tel: 251 9 20 49 98 20.

INTRODUCTION

A visual comparison of climate and vegetation on a global scale immediately reveals a strong correlation between climatic and vegetation zones. In turn, vegetation cover affects climate via alteration of the physical characteristics of the land surface like albedo, roughness, water conductivity (bio-geophysical mechanisms) and atmospheric gas composition, for example, CO_2 and CH_4 (biogeochemical effects) (Brokivn, 2002). Terrestrial vegetation depends on and affects land surface-atmosphere interactions as the primary link for moisture (evapo-transpiration) and energy (latent) exchange through its physiological properties, rooting depth and stomatal resistance), and its influence on surface roughness, and albedo (Bao et al., 2014). For instance, recent studies have reported a strong land-atmosphere coupling in West Africa, where by vegetation dynamics play a significant role in regulating the West African monsoon and therefore rainfall distribution (Hales et al., 2006). In South Africa, Williams and Kniveton (2012) reported increases and decreases in annual rainfall, based on idealized scenarios of expanding savanna and desert cover, respectively.

Recent studies on the climatic impacts of tropical deforestation have consistently shown increased warming and reduced evapo-transpiration and precipitation (Snyder, 2010). An improved characterization of spatial and temporal vegetation patterns is therefore important to not only assess landscape conditions but also to improve land surface model predictions and identify significant regional and global scale climate tele-connections. Multispectral band combinations of these datasets have aided the retrieval of long time series of land surface variables widely used to examine trends in vegetation dynamics at global, regional and national scales (Julien and Sobrino, 2009; Bao et al., 2014), impacts of vegetation on water and energy flux (Hu et al., 2009), as well as the correlation between vegetation and climate conditions (Bao et al., 2014). In coniferous canopies as one-half the total needle surface area per unit vegetated ground area, characterizes the physiologically functioning surface area for energy, mass and momentum exchange between the vegetated land surface and the planetary boundary layer. Hence, it is widely used by the global change research community to assess and quantify vegetation dynamics and their effects (Bobée et al., 2012; Cook and Pau, 2013).

Causes of climate change

First we have to understand the cause of climate change before we go any further, so factors that can shape climate are called climate forcing or “forcing mechanisms. Forcing mechanisms can be either “internal” or “external”. Internal forcing mechanisms are natural processes within the climate system itself (e.g. the thermohaline circulation). External forcing mechanisms can be either natural or anthropogenic (e.g., increased emissions of greenhouse gases). Whether the initial forcing mechanisms is internal or external the response of the climate system might be fast (e.g. a sudden cooling due to airborne volcanic ash reflecting sunlight), slow (e.g., thermal expansion of warming ocean water), or a combination (e.g. sudden loss of Albedo in the arctic as sea ice melts, followed by more gradual expansion of the water) (Spracklen et al., 2008). Therefore, the climate system can respond abruptly but the full response to forcing mechanisms might not be fully developed for centuries or even longer.

Direct effect of climate change on plant growth and ecosystem productivity

Plant growth and biomass production are important measures of plant responses to changing climate and elevated CO_2. Also, plant growth and biomass production can be limited by one or more climatic limiting factors, including air and soil temperatures, soil water availability, and solar radiation. Ecosystem model simulations of global terrestrial biomes suggest that temperature and water availability are the dominant climatic factors limiting net primary productivity globally, with solar radiation being the dominant limiting factor for only about 5 percent of the biomes (Churkina and Running, 1998). Given the diverse range of environments and biomes in the Pacific Northwest, all three climatic limiting factors are likely to operate in some regions and seasons, but winter temperatures and water limitations are considered the dominant controls on leaf area and net primary productivity in Pacific Northwest ecosystems (Grier and Running 1977; Gholz 1982). Soil nutrients (especially nitrogen) are another important factor limiting vegetation growth and productivity throughout much of the Pacific Northwest, which, though not directly climate-related, may modify vegetation structure and productivity (Gholz, 1982).

Overall, research suggests that warming air and soil temperatures will enhance plant growth and ecosystem production, given sufficient water availability (Boisvenue and Running, 2006, 2010). Warmer temperatures are expected to increase net carbon gain as respiration acclimates to warmer temperatures more than photosynthesis, allowing plants to adjust and maintain carbon-use efficiency (Maseyk et al., 2008). Temperature effects on phenology will tend to extend the growing season and, potentially, plant growth. Increased availability of soil N_2 could also increase growth and productivity. All of these potential gains, however, depend on adequate availability of soil water, which is likely to decline with increasing temperatures.

Vegetation response to rising CO_2 and temperature changes

Increase in CO_2 affect the plant in many ways also some studies indicate climate driven increases in global net primary after eventual acclimatization to higher CO_2. However, short term photosynthetic responses are decreased (initial increases in growth and yield stop). In fact, long term exposure to elevated CO_2 leads to the accumulation of carbohydrates in the photosynthetic tissues of the plant and this in turn leads to a reduction in photosynthetic rates (Bisgrove and Hadley, 2002). Also plants that do respond to elevated CO_2 produce tissue with lower nutrient concentrations (reduced leaf nitrogen (N_2) content) (Fangmeier et al., 2002). Moreover, increased CO_2 makes C_3 plants grow larger initially, plants growing faster and larger need more nutrients such as nitrogen with cascade effects on soil quality (Elstein and Mills, 2006). Also when CO_2 rise it reduce transportation inside the plant because Plants in increased CO_2 environments frequently either open their stomata less widely or keep their stomata completely closed more often, therefore reducing transpiration occurs, Even if all vegetation’s affect by rice of CO_2, different species respond differently. Whilst many species of plants acclimatize to elevated CO_2 relatively quickly; many others do not. Plants with growth strategies or photosynthetic pathways that allow them to take advantage of changing condition in any given habitat will gain a relative advantage over those that do not. Species with rapid growth rates may be responsive than slower grounding species. Within these responses, there will also be a genetic performances and varying genetic adaptability of species (Harte et al., 2004).

The direct effect of warming in plants and ecosystems will be complex because temperature impacts virtually all chemical and biological processes. However, the effect of temperature changes is likely to be larger and more important than any other factor (Kehlenbeck and Schrader, 2007). Too much heat affects the plant production. The drought in Europe in 2003 combination unusually high temperatures with water stress and reduced primary productivity by 30% (Clais et al., 2003). If temperature increases too much, faster respiration may tip the balance towards plants becoming a CO_2 source. Temperature rise may also affect habitat composition, since generally; C_3 plants are more sensitive to heat stress than C_4 and CAM plants (Ehleringer et al., 1997). Also unpredictable weather causes a lot of damage to the plants of many species, certainly in short term, it is not small differences in temperature that will affect them most, but rather the likelihood of sudden weather events, for example sudden frosts after periods of warmth (Kehlenbeck and Schrader, 2007). It is not just the magnitude of the change but the unpredictability of the change. Early onset of growth in response to mild weather combined with unexpected frosts is likely to cause significant damage to plants.

Effect of climate on seed production

Seed production can be influenced by climate and elevated atmospheric CO_2 (Jablonski et al., 2002; Ladeau and Clark, 2006). Warmer air and soil temperatures can advance flowering phenology in plants (Dunne et al., 2003; Parmesan, 2006; Beaubien and Hamann, 2011). Although earlier flowering can promote increased seed production and viability (Richardson et al., 2005; Walck et al., 2011), it can also expose plants to frost damage and reduced seed production, particularly at high elevations and latitudes (Inouye, 2008; Beaubien and Hamann, 2011). Climate-induced shifts in reproductive phenology can also alter plant reproductive capacity by altering phenological synchrony between plants and insect pollinators or herbivores (Hegland et al., 2009; Liu et al., 2011). Studies of seed mating in trees suggest that temperature and precipitation (water availability) may act at different stages of flowering and fruiting to influence seed production (Way et al., 2009; Selås et al., 2002). In general, however, the climatic and other environmental factors influencing seed production and viability are still poorly understood for most species, making it difficult to project responses to future climatic changes.

Effect of climate on productivity and nutrient cycling

Experimental studies have shown that elevated CO_2, warming temperatures, and increasing precipitation can all increase plant growth and net primary production across a wide range of terrestrial ecosystems (Hyvönen et al., 2007; Norby and Zak, 2011; Wu, 2011; Dieleman et al., 2012) although combined effects are not always additive (Wu, 2011; Dieleman et al., 2012). On average, elevated CO_2 and warming temperatures increase biomass production alone and in combination, but elevated CO_2 stimulated fine root biomass production more than aboveground biomass production (Dieleman et al., 2012; Norby and Zak, 2011; Wu, 2011). In a young aspen (Populustremuloides Michx) forest, elevated CO_2 increased net primary productivity by 26%. The mechanisms by which productivity is enhanced (and sustained) are still unclear, however, and appear to involve not only the direct effects of CO_2, temperature, and water availability (and their interactions) on photosynthesis, respiration, and growth, but also indirect effects on nutrient cycling and nitrogen availability (Sykes, 2009; Felzer et al., 2011).

Effects of climate change on plant productivity

Plant productivity is likely to increase in a climate that becomes warmer and where there is enough soil moisture. Precipitation per se has in general little direct effect on plants as they normally take up most of their water and nutrients from the substrate or soil on which they are growing, though precipitation is clearly important for the level of atmospheric and soil moisture (Sykes, 2009). The humidity of the air influences movements in the stomata or pores within leaves, a response that controls the flow of carbon dioxide in and water out of the plant. Plants need to maintain a balance between growth and survival. Plants require photosynthesis and the production of carbohydrates, which requires CO_2, for growth; and stomata need to be open to allow carbon dioxide to diffuse into the leaves. However, open stomata also mean the loss of water through transpiration (Sykes, 2009). In wet areas the balance between these two requirements is less of a problem than in drier areas, where survival and growth have to be balanced. Increasing atmospheric carbon dioxide has been suggested as having the potential to increase plant productivity and growth, both through the fertilization effect of more carbon dioxide available for photosynthesis and the role it may play in plant water use efficiency.

There is much discussion about these aspects and various long-term free-air carbon dioxide enrichment (FACE) experiments are underway in different ecosystems to assess the effect of increased levels of carbon dioxide on ecosystems (Ainsworth and Long, 2005). Results are mixed but tend to show that there is a fertilization effect at least in young forests. However, long-term effects and the effect of plant acclimation to carbon dioxide are not clear.

Response of photosynthesis to change in temperature

Photosynthesis can be strongly affected by temperature (Berry and Raison, 1982; Medlyn et al., 2002). Photosynthesis is a biochemical process and its overall temperature response can be understood in terms of the temperature dependencies of its component processes and their well-known interactions (Farquhar et al., 1980; Farquhar and von Caemmerer, 1982; Kirschbaum and Farquhar, 1984; Medlyn et al., 2002). At low to moderate temperatures, the activity of each of these component processes increases with increasing temperature in accordance with the Arrhenius relationship (Farquhar et al., 1980; Berry and Raison, 1982; Medlyn et al., 2002). At higher temperatures, photosynthesis decreases due to conformational changes in key enzymes. This decrease is reversible at moderately high temperatures but becomes increasingly irreversible with length and intensity of high temperature exposure.

Photosynthetic responses to temperature are thus highly dependent on species and growth conditions. All plants appear to be capable of a degree of adaptation to growth conditions, and it is important to note that photosynthesis in some species can function adequately up to 50°C (Kirschbaum, 2004). This suggests that even with considerable global warming, some plants will be able to continue to photosynthesis adequately, provided they have sufficient water. Some species, however, are able to acclimate more fully than others. For example, *A. sabulos a* performed well when grown in low temperatures, but photosynthetic rates were much reduced in plants grown at high temperature. The opposite pattern was apparent in *T. oblongifolia.* So that temperature increases would be likely to favour *T. oblongifolia* at the expense of *A. sabulosa* (Kirschbaum, 2004).

Indirect impacts of climate change on plants

All species are likely to be not only directly impacted by the changes in environmental condition discussed above also indirectly through their interactions with other species. While direct impacts may be easier to predict and conceptualize, it is likely that indirect impacts are being equally important in determining the response of plants to climate change (Walther et al., 2005). A species whose distribution changes as a direct result of climate change may “invade” the range of another species for example, introducing a new competitive relationship. The range of a symbiotic fungi associated with plant root may directly change as a result of altered climate, resulting in a change in the plant distribution (Enookon, 2014). A new grass may spread into a region, altering the fire regime and greatly changing the species composition. A pathogen or parasite may change interactions with a plant, such as a pathogenic fungus becoming more common in an area where rainfall increases. Increased temperature allows herbivores to expand further into Alpine regions, significantly impacting the composition of Alpine (Enookon, 2014). There are innumerable examples of how climate change could indirectly affect plant species, most of which will be extremely difficult to predict.

Adaptation of plants to climate change

Plants can/do adapt to changes in their environment, with a classic example coming from the rapid evolution of heavy metal tolerance in plants on mine site tailings (Antonivics et al., 1971) and more recent examples coming from herbicides resistance in a populations of weeds (Roy, 2004). However, plant adaptive responses to climate change are likely to be slower than plant responses to single pollutants, since adaptation to pollutants normally only involves one or two traits whereas adaptation to climate change is likely to involve many traits. The fossil record indicates that in the past, species have been able to adapt or move in response to climate change, but this has been dependent on a natural landscape. Further, from the perspective of the world’s plant species, current changes in climate are occurring in the context of many other stresses such as pollution, land use change and population increase (Enookon, 2014). A climate that is more sensitive than anticipated, with changes occurring sooner and more intensely than predicted (Christner et al., 2008). The extent of future climate change depends on what we do now. The smaller climatic shift the more species are likely to be able to persist, and the greater genetic diversity preserved. Biodiversity equals ability to adapt (Enookon, 2014). Healthy ecosystems are more likely to be able to adapt to future climate change, and continue to provide us with ecosystem services vital to our own existence.

RANGELAND MANAGEMENT AND CLIMATE CHANGE MITIGATION

A rational approach to responding to the uncertainty of climate change requires attention to both mitigation and adaptation activities. Mitigation, in contrast to adaptation, involves the reduction of greenhouse gas emissions and enhancement of greenhouse gas sinks (IPCC, 2007; de Steiguer et al., 2008). The goal of mitigation is to stabilize atmospheric greenhouse gas concentrations at a level that would prevent human interference with the natural climate system. Several methods for reducing emissions have been suggested for various sectors of the global economy. These include increased energy efficiency, the use renewable energy sources such as solar and wind, the use of biofuels and hybrid energy vehicles, recycling, greater use of public transportation, improved land use planning, and management of methane emissions. Most credible analyses of the range of actions necessary to meet society's energy needs while lowering greenhouse gas emissions include the use of both emission reduction and sequestration technologies and practices (de Steiguer et al., 2008).

The sequestration technology that has garnered the most attention, based on capacity, is geologic sequestration, extracting carbon dioxide (CO_2) from the atmosphere and storing it in geologic formations for long periods of time (>1,000 years). Although geologic sequestration offers great potential, many of the necessary technologies are unproven or not currently cost effective. Other sequestration technologies, such as ocean fertilization, have potential environmental downsides. Terrestrial sinks, on the other hand, are viable with current technology and are largely environmentally neutral or beneficial (Pacala and Socolow, 2004; de Steiguer et al., 2008). Natural terrestrial carbon sinks can be enhanced by practices and activities that increase carbon storage carbon and include improved cropland and rangeland management, reforestation, and reduced deforestation (Capoor and Ambrosi, 2007; de Steiguer et al., 2008).

Both emission reduction and sink enhancement mitigation measures are being initiated at city, state, regional, and global levels through both voluntary actions (Capoor and Ambrosi, 2007; de Steiguer et al., 2008) in the private sector and as a result of national laws and policies such as those passed by the US Congress (Tietenberg, 2002; de Steiguer et al., 2008). Many public policies and business analysts' confidently predict a hybrid approach that will integrate government-mandated and -supported emission reduction strategy and a private sector market to discover the most cost-effective means of meeting targets (de Steiguer et al., 2008).

CONCLUSIONS

Vegetation cover is important for the sustainability of urban ecosystems; however, this cover has been undergoing substantial changes in the world. There is a relationship between climate and vegetation cover, in the sense that high temperature and low levels of rainfall affect the abundant of the vegetation cover. In general, there was an increase in temperatures; there is strong correlation between vegetation cover and climate change. Nowadays global warming is the major concern the only option to control this problem is planting tree or preventing of deforestation for the improvement of vegetation cover, after this the world's climate became stable and reduce natural disaster like wild fire. Also sound range management practices must be used to reduce the negative impacts of overgrazing on natural vegetation cover.

CONFLICT OF INTERESTS

Authors declare no conflict of interests

REFERENCES

Ainsworth EA, **Long** SP, **2005**. What have we learned from 15 years of free-air CO2 enrichment (FACE)? A meta-analytic review of the responses of photosynthesis, canopy properties and plant production to rising CO2. New Phytol, 165: 351–372.

Antonivics J, Bradshaw A, Turner R, **1971**. Heavy metal tolerance in plants. Adv Ecol Res, 7: 1-85.

Bao G, Qin Z, Bao Y, Zhou Y, Li W, Sanjjav A, **2014**. NDVI-Based Long-Term Vegetation Dynamics and Its Response to Climatic Change in the Mongolian Plateau. Remote Sens, 6(9): 8337–8358, doi:10.3390/rs6098337.

Beaubien E, **Hamann** A, **2011**.Spring flowering response to climate change between 1936 and 2006 in Alberta, Canada. BioScience, 61: 514–524.

Berry JA, **Raison** JK, **1982**. Responses of macrophytes to temperature. In Physiological Plant Ecology I. Responses to the Physical Environment, Encyclopedia of Plant Physiology, New Series,Vol.12 A (Lange, O. L., Nobel, P. S., Osmond, C. B., and Ziegler, H., eds.), Berlin, Heidelberg, New York: Springer-Verlag, pp.277–338.

Bisgrove R, **Hadley** P, 2002.Gardening in the global greenhose: The impacts of future landuse and climate on the red list status of the Proteaceae in the cape floristic region, South Africa. Glob Chang Biol, 69: 79-91.

Bobée C, Ottlé C, Maignan F, de Noblet-Ducoudré N, Maugis P, Lézine AM, Ndiaye M, **2012**. Analysis of vegetation seasonality in Sahelian environments using MODIS LAI, in association with land cover and rainfall. J Arid Environ, 84: 38–50. doi:10.1016/j.jaridenv.03.005.

Boisvenue C, **Running** SW, **2006**. Impacts of climate change on natural forest productivity evidence since the middle of the 20th century. Glob Change Biol, 12: 862–882.

Boisvenue C, **Running** SW, **2010**. Simulations show decreasing carbon stocks and potential For carbon emissions in Rocky Mountain forests over the next century. Ecol Appl. 20: 1302–1319.

Brokivn V, **2002**.Climate-Vegetation interaction. J. Physi.IV France 12: pp. 52-57.

Capoor K, **Ambrosi** P, **2007**. State and trends of the carbon market, 2007. Washington, DC, USA: The World Bank. 45.

Christner BC, Morris CE, Foreman CM, Cai R, Sands DC, **2008**. "Ubiquity of Biological Ice Nucleators in Snowfall" Science, 319(5867): 1214.

Churkina, G, **Running** SW, **1998**. Contrasting climatic controls on the estimated productivity of global terrestrial biomes. Ecosystems, 1: 206–215.

Clais P, Reichstein M, Viovy N, Granior A, Oge J, Allard V, Aubinet M, Buchmann N, Bernhofer C, Carrara A, Chevallier F, De Noblet N, Friend A, Friedlingstein A, Grunwald P, Heinesch B, Keronen P, Knohl A, Krinner A, Loustau D, Manca C, Matteucci G, Miglietta F, Ourcival J, Papale D, Pilegaard K, Rambal S, Seufert G, Soussan J, Sanz E, Schulze E, Vcsala T, Valentini R, **2003**. Europe-wide reduction in primary productivity caused by the heat and drought in 2003. Nature, 437: 22.

Cook BI, **Pau** S, **2013**. A global assessment of long-term greening and browning trends in pasture lands using the GIMMS LAI3g dataset. Remote Sens, 5(5): 2492–2512. doi: 10.3390/rs5052492.

de Steiguer JE, Brown JR, Thorpe J, **2008**. Contributing to the mitigation of climate change using rangeland management. Rangelands, 30(3): 7-11.

Dieleman WIJ, Vicca S, Dijkstra FA, Hagedorn F, Hovenden MJ, Larsen KS, Morgan JA, Volder A, Beier C, Dukes JS, King J, Leuzinger S, Linder S, Luo Y, Oren R, de Angelis P, Tingey D, Hoosbeek MR, Janssens IA **2012.** Simple additive effects are rare: a quantitative review of plant biomass and soil process responses to combined manipulations of CO_2 and temperature. Glob Change Biol, 18: 2681–2693.

Dunne JA, Harte J, Taylor KJ, **2003**. Subalpine meadow flowering phenology responses to climate change: integrating experimental and gradient methods. Ecol Monogr. 73: 69–86.

Ehleringer J, Thure E, Cerling B, Helhker R, **1997**. C4 photosynthesis, atmospheric CO2 and climate. Oecologia, 112: 285-299.

Elstein P, **Mills** E (eds.) **2006**. Climate Change Future, Health, Ecological and Economic Dimensions. Second Printing the Center for Health and the Global Environment, Harvard Medical School. http;//www.climatechangefutures.org/pdf/CCF.

Enookon T, **2014**. A Review on Climate Change Effects on Vegetation – Past and Future*.* Int J Ecol Sci Environ Eng*,* 1(2): 27-42.

Fangmeier A, de Temmerman L, Black C, Persson K, Vorne V, **2002**. Effects of elevated CO and/or ozone on nutrient concentrations and nutrient uptake of potatoes, Eur J Agron*,* 17(4): 353-368.

Farquhar GD, **von Caemmerer** S, **1982**. Modelling of photosynthetic response to environmental conditions. In PhysiologicalPlant Ecology II. Water Relations and Carbon Assimilation, Encyclopedia of Plant Physiology, New Series, Vol.12B (Lange, O. L., Nobel, P. S., Osmond, C. B., and Ziegler, H., eds.), Berlin, Heidelberg,New York: Springer-Verlag, pp.549–588

Farquhar, GD, von Caemmerer S, Berry J, **1980**. A biochemicalmodel of photosynthetic CO2 assimilation in leaves of C3 species. Planta, 149: 78 –90

Felzer BS, Cronin TW, Melillo JM Kicklighter DW, Schlosser CA, Dangal SRS, **2011**. Nitrogen effects on carbon-water coupling in forests, grasslands, and shrublands in the arid western United States. J Geophys Res, 116: G03023. Doi: 10.1029/2010JG001621.

Gholz HL, **1982**. Environmental limits on above-ground net primary production, leaf-area, and biomass in vegetation zones of the Pacific Northwest. Ecology, 63: 469–481.

Grier CC, **Running** SW, **1977**. Leaf area of mature northwestern coniferous forests-relation to site water-balance. Ecology, 58: 893–899.

Hales K, Neelin JD, Zeng N, **2006**. Interaction of vegetation and atmospheric dynamical mechanisms in the mid-Holocene African monsoon. J Clim, 19(16): 4105–4120, doi:10.1175/JCLI3833.1.

Harte J, Ostling A, Green J, Kinzig A, **2004**. Climate change and extinction risk arising from: C. D. Thomas*.* Nature*,* 427: 145-148.

Hegland MA, Hulme PE, McGlone MS, Duncan RP, **2009**. Are tree lines advancing? A global meta-analysis of tree line response to climate warming. Ecol Lett, 12: 1040–1049.

Hu Z, Yu G, Zhou Y, Sun X, Li Y, Shi P, Wang Y, Song X, Zheng Z, Zhang L, Li S, **2009**. Partitioning of evapotranspiration and its controls in four grassland ecosystems: Application of a two-source model. Agric For Meteorol, 149(9), 1410–1420. doi:10.1016/j.agrformet.2009.03.014.

Hyvönen R, Ágren GI, Linder S, Persson T, Cotrufo MF, Ekblad A, Freeman M, Grelle A, Janssens IA, Jarvis PG, Kellomaki S, Lindroth A, Loustau D, Lundmark T, Norby RJ, Oren R, Pilegaard K, Ryan MG, Sigurdsson BD, Strömgren M, van Oijen M, Wallin G, **2007**. The likely impact of elevated [CO2], nitrogen deposition, increased temperature and management on carbon sequestration in temperate and boreal forest ecosystems: a literature review. New Phytol, 173: 463–480.

Inouye DW, **2008**. Effects of climate change on phenology, frost damage, and floral abundance of montane wildflowers. Ecology, 89: 353–362.

Intergovernmental Panel on Climate Change (**IPCC**), **2007**. Climate change 2007: mitigation. In: B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, and L. A. Meyer [eds.]. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers, 24 p. Cambridge, United Kingdom: Cambridge University Press. pp. 818.

Jablonski LM, Wang X, Curtis PS, **2002**. Plant reproduction under elevated CO2 conditions: a meta-analysis of reports on 79 crop and wild species. New Phytol, 156: 9–26.

Julien Y, **Sobrino** JA, **2009**. Global land surface phenology trends from GIMMS database. Int J Remote Sens, 30(13): 3495–3513. doi:10.1080/01431160802562255.

Kehlenbeck H, **Schrader** G, **2007**. Climate Change, Happy future for plant pests? Ln: Secretariat of the convention on Biological Diversity, 2007. Emerging Issues for Biodiversity Conservation in a Changing Climate.CBDTechnical Series No. 29, Montreal, Canada.

Kirschbaum MUF, **2004**. Direct and Indirect Climate Change Effects on Photosynthesis and Transpiration. ISSN 1435-8603.

Kirschbaum MUF, **Farquhar** GD, **1984**. Temperature dependence of whole-leaf photosynthesis in *Eucalyptus pauciflora* Sieb. ex Spreng. Aust J Plant Physiol, 11: 519 –538.

Ladeau SL, **Clark** JS, **2006**. Elevated CO2 and tree fecundity: the role of tree size, interannual variability, and population heterogeneity. Glob Change Biol, 12: 822–833.

Liu Y, Reich PB, Li G, Sun S, **2011**. Shifting phenology and abundance under experimental warming alters trophic relationships and plant reproductive capacity. Ecology, 92: 1201–1207.

Maseyk RW, Heffernan P, Brink S, Crandall D, Deneke F, Galik C, Gee E, Helms JA, McClure N, Mortimer M, Ruddell S, Smith M, Stewart J, **2008**. Forest management solutions for mitigating climate change in the United States. J For, 106: 115–117.

Medlyn BE, Barton CVM, Broadmeadow MSJ, Ceulemans R, De Angelis P, Forstreuter M, Freeman M, Jackson SB, Kellomä-ki S, Laitat E, Rey A, Sigurdsson BD, Strassemeyer J, Wang K, Curtis PS, Jarvis PG, **2002**. Stomatal conductance of forest species after long-term exposure to elevated CO2 concentration: asynthesis. New Phytol, 149: 247– 264.

Norby RJ, **Zak** DR, **2011**. Ecological lessons from free-air CO2 enrichment (FACE) experiments. Annu Rev Ecol Evol Syst, 42: 181–203.

Pacala S, **Socolow** R, **2004**. Stabilization wedges: solving the climate problem for the next 50 years with current technologies. Science, 305: 968–972.

Parmesan C, **2006**. Ecological and evolutionary responses to recent climate change. Annu Rev Ecol Evol Syst, 37: 637–669.

Richardson SJ, Allen RB, Whitehead D, Carswell FE, Ruscoe WA, Platt KH, **2005**. Climate and net carbon availability determine temporal patterns of seed production by *Nathofagus*. Ecology, 86: 972–981.

Roy B, **2004**. Rounding up the Costs and Benefits of Herbicide Use. Proc Natl Acad Sci U S A, 101: 13974-13975.

Selås V, Piovesan G, Adams JM, Bernabei M, **2002**. Climatic factors controlling reproduction and growth of Norway spruce in southern Norway. Can J For Res, 32: 217–225.

Snyder PK, **2010**. The influence of tropical deforestation on the Northern Hemisphere climate by atmospheric teleconnections. Earth Interact, 14(4): 1–34. doi:10.1175/2010EI280.1.

Spracklen DV, Bonn B, Carslaw KS, **2008**. Borealforests, aerosols and the impacts on clouds and climate. Philos Trans Royal Soc A: Math Phy Eng Sci, 366(1885): 4613.

Sykes MT, **2009**. Climate Change Impacts: Vegetation. In: Encyclopedia of Life Sciences (ELS). John Wiley & Sons, Ltd:Chichester.

Tietenberg T, **2002**. The tradable permits approach to protecting the commons: what have we learned? In: E. Ostrom et al. [eds.]. The drama of the commons. Washington, DC, USA: The National Academies Press. p. 197–232.

Walck JL, Hidayati SN, Dixon KW, Thompson K, Poschlod P, **2011**. Climate change and plant regeneration from seed. Glob Change Biol, 17: 2145–2161.

Walther G, Berger S, Sykes T, **2005**. An Ecological' footprint' of climate change. Proc Royal Soc B, 272: 1427-1432.

Williams CJR, **Kniveton** DR, **2012**. Atmosphere-land surface interactions and their influence on extreme rainfall and potential abrupt climate change over southern Africa. Clim Change, 112(3): 981–996. doi:10.1007/s10584-011-0266-7.

Way DA, Ladeau SL, McCarthy HR, Clark JS, Oren R, Finzi AC, Jackson RB, **2009**. Greater seed production in elevated CO2 is not accompanied by reduced seed quality in *Pinus taeda* L. Glob Change Biol. 16: 1046–1056, doi: 10.1111/j.1365-2486.2009.02007.x.

Wu M, **2011**. Projected increase in continent alrun off due to plant responses to increasing carbon dioxide. Nature, 4481: 1037-1041.

Citation: Getabalew M, Alemneh T, Zewdie D, 2020. Effect of rangeland vegetation cover on climate change mitigation. Int J Ecol Ecosolution, 7(2): 16-22.