Review article

A REVIEW OF SIMILARITY BETWEEN SEED BANK AND STANDING VEGETATION UNDER GRAZING

Gantuya Jargalsaikhan

Research Institute for Animal Husbandry

gant_416@yahoo.com

ABSTRACT

In recent years, many researchers have stated the importance of above and belowground interactions to better understand succession in plant communities and state and transition dynamics in rangelands. A review indicate that improved knowledge the soil´s seed bank is a key element in understanding above and belowground interactions and plant community dynamics in grazed rangelands. The aim was to study current successional theories, with special emphasis on state and transition models to understand rangeland ecosystem dynamics under grazing. I thoroughly reviewed 28 articles published that summarized and provided specific values on similarities between above and belowground communities to identify under grazing across different ecosystem

Vegetation dynamics above and below-ground; succession states, transitions and thresholds

The assessment of the relative importance of abiotic and biotic factors as well as their interactive between reliance in rangeland natural development and restoration is an continuously scientific challenge in all countries [1]. The role of biotic interaction in plant succession, especially how biotic interactions between plants, aboveground and belowground organisms work out into plant species replacement, is less well understood. Succession is the change in composition of natural vegetation over time, and the processes of colonization, competition, disturbance, senescence, and replacement determine the rate and direction of the succession. In most grassland ecosystems, grazing has been a main disturbance factor and should be considered as a driver of the successional stages [2].

Same time some comprehensive recent reviews have explicitly recognized the importance of interaction between plants and soils for underpinning ecosystem restoration. Especially successful restoration of aboveground organisms and interactions could potentially benefit from explicit consideration of the belowground community and trophic relationship. Aboveground and belowground components of ecosystems are strongly linked through a variety of both direct and indirect interactions that operate across level of ecological organization. Last 35 years, the science of restoration ecology has increasingly sough to improve its conceptual basis, including through drawing on basic ecological concepts such as succession theory, threshold dynamics and state transitions, community assembly rules, and niche differentiation [3].

Aboveground-belowground ecology looks at plants, aboveground biota and soil biota as parts of the same system, in which aboveground and belowground individuals, populations and communities influence each other [4]. Especially grazing processes affect the legacy of plant roots in the soil, due to the poor dispersal capacity and long survival of many soil organisms. However, the exploration of aboveground-belowground interactions may depend on plant species traits and environmental conditions. Previous studies have shown that soil seed bank may play an important role in the restoration management of previously overgrazed dry grassland communities were the seeds represent an important refuge for species disappearing from the vegetation after cessation of essential for successful habitat restoration and management [5]. If the density of persistent seeds of typical grassland species in the soil seed bank is sufficient, successful grassland restoration might still be possible [5].

There is conflicting evidence concerning the potential of soil seed banks to contribute to grassland restoration. The majority of previous studies have concluded that soil seed banks in temperate semi-natural grassland tend to be relatively small because characteristic grassland species do not possess seeds that persist in the soil [4]. Consequently, the significance of the soil seed bank for the restoration of calcareous grassland communities has been assumed by these authors to be low [6]. However, other studies have found equivalent seed bank densities and species richness levels in open grassland and overgrown sites [7]. The number of seedlings of different species emerging from the soil samples was used as a measure of the number of viable seeds in and the composition of the seed bank [8]. The clearly understood and recognized role of natural disturbance as drivers of linkages between the aboveground and belowground, moreover it can drive critical ecosystem transition between human driven states and alternate desired restoration states (i.e. threshold dynamics) [3]. An alternative procedure for reassessment/ or rangeland evaluation, including state and transition, thresholds, and rangeland health. Briske et al. (2005) has pointed out, "The need for alternative evaluation procedures originated from the inability of the traditional method of range condition and trend analysis (range model) to account for the entire spectrum of vegetation dynamics that occurred on rangelands" (Briske et al. 2005, page 3-4). The range model is generally depicted to show that grazing intensity proportionally counteracts secondary succession, in a continuous directional manner, is this connection has received substantial criticism contending that it is an effective, over simplification of vegetation dynamics on many rangeland ecosystem [9]. So this model is largely a univariate approach that emphasizes grazing as the primary driver of vegetation dynamics. However, according to "The historic plant community, as defined in the traditional range model, has been adopted as an ecological reference within state and transition models developed", some people developed by range model [9]. Referring to Briske et al. (2003) "State and transition models includes knowledge of potential alternative vegetation states on a site, potential transition between states and opportunities to achieve favorable transition between vegetation states and hazards to avoid unfavorable transitions" Briske et al. 2003, page 606-607). "Therefore this models can represent vegetation change along several axes, including fire regimes, soil erosion, weather variability, and management prescriptions, in addition to the secondary succession-grazing axis associate" (Briske et al. 2008, page 360-361).

Land use changes, vegetation composition and ecosystem development can, through modification and/or fragmentation of habitats, cause decline in biodiversity and lead to degradation of soil and water [10]. In addition to human land use and livestock overgrazing, elevated average air temperatures, and decreased annual precipitation will put a further stress on these rangelands, resulting in reduced feed production, increased erosion rates, and in some situations desertification [11].

What is seed bank?

A seed is a structure in which the mostly completely developed plant embryo is disseminated, and which enables the embryo to survive the period between seed maturation and seedling establishment [12]. Seed dormancy depends on seed structure, especially those surrounding the embryo, and on factors affecting the growth potential of the embryo. Seed dormancy is defined as the failure of the intact viable seed to complete germination under favorable conditions. It is controlled by several environmental factors, such as light, temperature and duration of seed storage [13].Very little is known about how long seeds can remain dormant, because the time scales necessary for such experiments are so long. Gurevitch et al. (2006) describes the famous experiment on seed germination that William J. Beal began in 1879. His successors continued measurements every 5 years for the first 40 years and at 10 years intervals after that time, and tested the viability of the seeds. For 16 species, all seeds germinated within 50 years [14]. These experiments showed how variable the longevity of seeds of different species can be. It is documented that seeds of some species can retain their viability for periods of at least 100 years [15] .

The seed bank is the collection of seeds in the soil. This term is sometimes used to refer to the seeds of a single species and sometimes to the seeds of an entire community [14]. Seed bank reflect vegetation history, although the floristic representation is biased because of difference amongst species in seed production, dispersal and longevity in the soil. The abundances of species in the seed bank may have relationship to those of the plants growing in the same spot. Many species growing aboveground have few seeds in the soil. Other species may exist only in the seed bank at a given time [15].

The connection between a persistent seed bank and seed sizes is closely linked with the probability of burial. Persistent seeds tend to be small and compact, while short-lived seeds are normally larger and either flattened or elongate [13]. Seed banks reflect vegetation history; however, the floristic representation is usually biased because of difference amongst species in seed production, dispersal and longevity in the soil [15]. The size of the seed bank is also affected by the nearness to disturbance. The decision of both size and composition of soil seed banks is important for understanding changes in current and future composition [16] and the potential for plant populations to persist in spite of climatic variation in grazed pastures [17]. Moreover, differences of seed attributes, like seed mass, are important in determining seed bank behaviour. Seed mass and longevity were found to be negatively correlated since smaller seeds are more likely to become buried [18]. In addition to soil seed bank densities, surface properties following disturbance can help to develop indicators to determine the severity of site degradation, which management action is required, and determine the potential for vegetation recovery [15].

Seed density in the litter/humus layer above the soils is extremely variable [15]. A reduction in organic debris may diminish inputs into the seed bank and decrease the capture of wind-blown seeds as they disperse across disturbed surfaces [19]. The current seeds in the soil are potentially useful in restoration projects where establishment of plant cover is desired, although it can be a more important source of regeneration of undesirable species [15]. If seed bank no long exist, re colonization is slow as seed has to be carried to the site by wind, water or animals.

The existence of a seed bank can have important demographic consequences for a population and helps to buffer a population against year-to-year variation in demographic rates. Seed bank can also affect evolution, first, by slowing the response of selection by maintaining genotypes produced in previous years. Also, mutation rates in seeds can be substantial, and seed banks can thus act as a source of genetic novelty [14].

In a study by Warr et al. (1993), soil under a climax community was found to contain viable seeds of most of the previous serial stages In addition most of the seed in the soil was derived locally rather than by immigration [15].

Because many seeds remain viable in the soil for long time periods of time, it is useful to divide the seed bank into seeds from species that persist for shorter than five years in the soil – named short-term persistent, and seeds from species which persist for longer than five years – named long-term persistent. These two strategies together with transient strategy form a useful seed bank classification [15].

Correlation between seed bank (below) and vegetation (above)

Correlation between soil seed bank and current vegetation has been studied in many different plant communities, to gain better knowledge of the role of seed banks in succession, regeneration after disturbances and for rehabilitation programms [20]. Better knowledge of the soil seed bank is a key element in understanding plant community dynamics and the great challenge to linking of aboveground and belowground ecosystems to improve integrated management of ecosystems [21].

Hopfensperger (2007) studied the relationship between above and belowground species composition in forests, grasslands, and wetlands. His study revealed low similarity between seed bank and vegetation composition. The similarity between above and below ground species composition seemed to depend on disturbance intensity or utilization. A suddenly and high intensity of disturbance led to higher similarity between seed bank and vegetation, whereas shortly after disturbance the similarity decreased. Hopfensperger´s main conclusion was that all forest studies found similarity above and below ground around 60%. Grassland studies indicated short dispersal distance could leading high similarity between seed bank and vegetation composition in grassland in desert grassland. In wetland high similarity on species composition in often annual dominated communities [22].

Lemenih and Teketay (2006) [23] revealed to changes in the species composition and density of viable seeds in the soil seed bank under deforestation and cultivation in tropical zone. However, they found relatively high similarity in species composition of the soil seed bank and selected natural forest. There was low similarity between soil seed bank and standing vegetation.

Those concepts presented relation between seed banks and vegetation as an important source of seed. In woodlands, early successional species have been destroyed from the aboveground vegetation but remain in the seed bank. Seeds of every plant growing should not remain in seed bank [24]. It's often difficult to detect transient species, mostly found in undisturbed habitats, because relations between aboveground and belowground species compositions are usually similar. Nonetheless disturbed habitats generally have less relation between the species present in the seed bank and the vegetation [18].

Zhan et al. (2007) [25] reports several studies on seed bank focusing on the different type of land use of agricultural importance: continuously grazed, rested (3 years), and in abandoned field. The results showed structure and species richness of the soil seed bank was closely related to the species composition of the current vegetation. In the study, more plant species were found in the above-ground vegetation than in the soil seed bank for both the grazed and rested 3 years field. Also dominant species in the soil seed bank in grazed field were similar to that in the rested 3 years field. They concluded a relatively high similarity for each of the three sites.

Martinez-Duro et al. (2012) [6] studied in long term abandoned area. Study revealed that time did not significantly affect species richness or seed bank density the study observed a high correlation between the species composition above and belowground in the seed bank layers of semi-arid gypsum habitat. The results indicated that the seed bank and aboveground vegetation were closely related over time, even though the composition and density of soil seed banks are very important for community dynamics in unfertile soils. Seed bank features were not determined by the time elapsed since disturbances, which in turn were most likely driven by changes in the composition of the aboveground vegetation.

Wellstein et al. (2007) [18] different grassland management types under land use history have strong effect on seed bank in correlation to aboveground vegetation. The result showed significant differences in the number of seeds between management types. However, similarity of species composition between seed bank, vegetation, quantitative seed bank traits, diversity and density, were significantly affected by current management. Thus, grassland management type was a major factor influencing seed bank composition.

Osem et al. (2006) [24] this study argued that, correspondence between seed bank and vegetation including the role of productivity in grazing area showed that low relation occurs in grassland dominated by perennial species. Higher relation has been observed in communities dominated by annuals, as in early successional stages. The Study found out that annual community correlation between the seed bank and vegetation varied differently, with productivity. Similarly annuals increased with production in the low potential range, and no correlation, or decreased slightly with low productivity. These studies revealed larger differences between grazed and un grazed plots in anticipation with further increases in productivity.

Also another study observed in relation to previous practical concept, considers the effect of [25] on the similarity between the two compartments. Zhao et al. (2011) also revealed similar results have concluded that there is higher relation between the two compartments in annual-dominated rangeland. Additionally, there are no correlations between seed bank and vegetation with low productivity. The main conclusion indicated that more important effects of on seed bank-vegetation correspondence depend on the dominance of annual or perennial plants.

Only a few studies have analyzed the impact of livestock grazing on seed bank composition [27]. Records of historical composition of the aboveground vegetation has often identified grazing as a main disturbance of grassland swards, creating gaps for seed germination, while at the same time limiting the rate of decolonization [18].

Agra and Ne'eman (2012) [20] studies indicated that moderate cattle grazing effects on rangeland. Samples of soil seed bank taken from the same patches and germinated under optimal greenhouse condition. Study showed that grazing exclusion decreased the similarity in species composition between aboveground vegetation and soil seed bank. This confirms similarity between aboveground vegetation and seed bank in the grazed areas which was lower in the non-grazed areas. The study shows that non-grazed soil seed bank plays a more important role than the spatial properties of the patch.

Tessema et al. (2012) [8] studied under lightly and heavy grazing intensity in semi-arid rangeland. Study showed higher similarity in species composition between above-belowground vegetation at the lightly grazed sites compared to the heavily grazed sites. However, mean correlation between the belowground and current vegetation was relatively low, indicating the effect of heavy grazing. The study concluded that the seeds of grass species available in the soil seed banks are unable to rapidly drive the transition from degraded conditions to perennial grass cover that represents better fodder value. Overestimated because viable and nonviable seeds cannot be recognized and separated [28]. For species which are relatively common in the seed bank, viability tests may be carried out and density estimates adjusted. The main problem of this method, however, is that small seeds may be lost during extraction. Extracting seeds from the soil is time consuming, particularly where large numbers of samples are involved, although samples may be stored prior to processing [16]. Another useful approach, which has been employed in a large number of studies, is enumeration by germination. The soil samples are placed in a greenhouse and watered regularly. After the first flush of seedlings have been identified and removed, the soil is stirred to promote further germination. The seeds of some species germinate rapidly, while others continue to germinate over an extended period time [16]. It is therefore necessary to keep the samples for a long time, two years or more, if an exhaustive estimate of all the viable seeds present is required. However, most studies have shown that, provided conditions are suitable, most germination occurs within the first two months, so there is little to be gained by keeping the samples for longer than six months. Germination methods provide more information about species composition whereas separation methods are more useful for studying variations in seed distribution, particularly of species with easily identifiable seeds [15].

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