MONITORING IN ICELANDIC RANGELAND

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ABSTRACT

Key words: rangeland, carrying capacity, line point intercept, gap intercept, degradation.

Rangelands are an important part of our planet, they cover between 30 and 70% of the world’s land, and are vital for providing economic value, biodiversity, and ecosystem services. The global issue of rangeland degradation, exacerbated by climate change and human activities, highlights the need for robust monitoring and sustainable management practices. In Uzbekistan, rangelands lands constitute about 50% of the country's area and play a crucial role in livestock production. However, overgrazing, and poor management have led to severe degradation, with increasing prevalence of unpalatable and harmful plant species, resulting in diminished rangeland productivity and accelerated desertification.

In Uzbekistan, a recent research project employed both traditional and remote sensing methods to evaluate soil parameters and biomass, offering valuable insights for sustainable land use. One of the main goals was to participate in fieldwork with the GróLind team around Reykjavík, and this provided invaluable hands-on experience. GróLind Iceland's program focuses on sustainable land management and uses several methods to monitor pasture health. By joining their field workers, experience was gained with the various tools and techniques used in monitoring.

In this study, I have explored the Gap Intercept Method and the Line-Point Method as tools for assessing the current state of land and monitoring changes vegetation cover over time. I found that the Gap Intercept Method is much easier to apply not required too much manpower and also yields more accurate results. With the goal of further refining these methods, I plan to implement them in the rangeland areas of Uzbekistan upon my return.

This study's findings are essential for developing policies and initiatives to restore and conserve Iceland and Uzbekistan rangelands.

1. INTRODUCTION

Rangeland

Rangelands are a significant part of our planet, covering between 30% and 70% of the land (Sant et al. 2014). Rangelands are areas of land where natural vegetation is primarily grasses, herbs, and shrubs (Alikhanov 2018). These lands are not suitable for farming crops but are good for grazing livestock. The amount of biomass, which is the total mass of all living plants, varies a lot depending on the climate. In dry, arid climates, there might be as little as 300 kilograms of biomass per hectare. In contrast, in wet, moist climates, there can be up to 5000 kilograms of biomass per hectare (Alikhanov 2018). These lands are crucial because they offer economic value, provide feed for livestock, contain one- third of the world's biodiversity and store half of the global soil carbon (Sant et al. 2014). Because of these benefits, it is particularly important to manage and monitor rangelands carefully.

In Uzbekistan, rangelands cover about 21.1 million hectares, which is about 47-50% of the country's total area. Of the rangelands, 60% are sandy rangelands, mainly found in the Kyzylkum desert pastureland. The biggest issue affecting sandy rangelands is the high and poorly managed number of sheep and goats (Rajabov et al. 2020). Majority of the farming in Uzbekistan's rangeland regions focuses on Karakul sheep breeding, with goat, cattle and horse husbandry following in importance. The total livestock population exceeds ten million head (Mahmudov 2006). Over 2.3 million people rely entirely on livestock production for their food and economic security (Yusupov 2003).

More than 1,500 plant species belonging to 50 families and 302 genera have been discovered in natural pastures of Uzbekistan (Allanazarova 2004). Of those species, 550 are classified as livestock feed. Historically, the vegetation cover of this area was important not only as a primary food source for wild herbivores, but also as a natural food source for grazing livestock in the area. The role of natural rangelands is crucial for the sustainable development of the livestock industry in Uzbekistan, particularly in desert regions. These rangelands serve as the sole source of natural feed for livestock throughout the year.

Rangeland degradation

Rangeland degradation is a matter of significant concern for an extensive range of the world's rangelands due to their importance in providing ecosystem services such as food, water, and livelihoods for many impoverished populations globally. Particularly, arid land biomes, which account for a significant part of the regions where pastoral livestock farming is a primary land use, constitute 51% of the Earth's terrestrial surface while sustaining 78% of the total global grazing territory (Asner et al. 2004).

Poverty and rangeland degradation are frequently linked to societies undergoing transitions, particularly in cases where there has been a significant modification in land tenure and land use. The dissolution of the Soviet Union serves as an example, whereby rangelands in Mongolia, such as many Central Asian nations, transitioned to a state of predominantly unrestricted access, resulting in a loss of regulation over the timing of grazing activities and the number of animals present. This shift has been documented by various researchers such as Mearns (1996), Fernandez-Gimenez (1997), and Bedunah and Schmidt (2004). Furthermore, the significance of conventional pastoral systems and Indigenous ecological knowledge has frequently been undervalued. The installation of fences and water infrastructure, lacking proper livestock management, notably exacerbated the degradation of land in various regions across Africa, Uzbekistan, and Mongolia (Walker and Janssen, 2002).

During the last two decades, the scope of desertification in Mongolia has expanded due to climate change, inappropriate human land use, and reduced precipitation, reaching 72% in 2006, 77.8% in 2010, and 77.8% in 2015, ultimately rising to 76.8% (Parliament of Mongolia 2022).

Over the last twenty years, Uzbekistan has witnessed substantial deterioration of its pasture lands, mainly due to unsustainable livestock grazing practices, inadequate upkeep, and various human-induced activities. Approximately 10 million hectares, or 42%, of the nation's rangelands have been identified as degraded (CACILM 2006). Nonetheless, evaluations of satellite data obtained remotely reveal that merely 17% of these rangelands exhibited a decrease in vegetation cover between 1982 and 2006 (Le et al. 2014). The principal factors contributing to the degradation of rangelands are overgrazing and deforestation, which have notably diminished the expanse of rainfed rangelands. The National Programming Frameworks for Central Asian countries (CACILM 2006) pinpointed several reasons for rangeland degradation, including "overgrazing, shrub cutting, land abandonment, excessive stocking, inadequate maintenance of rangeland infrastructure, insufficient economic and organizational capacity among farmers, and limited awareness of rangeland degradation issues and strategies" (Pender et al. 2009).

However, in recent years, the vegetation cover of rangelands in desert and semi-desert areas has increasingly been in a state of crisis due to several anthropogenic factors, particularly irregular grazing practices. This mismanagement has led to significant changes in the natural state of these rangelands (Nejad 2013).

Negative impacts of climate change such as decreased precipitation, and increased temperature are compounded by anthropogenic activities (Rakhimova et al. 2018). These factors have led to significant ecosystem degradation. This degradation is characterised by a decline in biodiversity and an accelerated process of desertification. These findings underscore the urgent need for comprehensive strategies to mitigate these adverse effects and restore ecological balance in affected areas.

PROJECT GOALS AND OBJECTIVES

The goal of the study is to examine different methods to assess ecosystem change. The objects are:

1. Comparison of established monitoring methods used in Uzbekistan, Iceland, Mongolia.

2. Join the GróLind field workers in the field around Reykjavík to get hands on experience and a better understanding of the monitoring method.

3. Develop methods to study spatio-temporal changes of vegetation structure along grazing intensity gradients and identify the indicative properties of rangeland vegetation in the condition of long-term livestock grazing.

METHODS

Approach

This approach focuses on studying the interactions between ecological factors (drought, sandy soil, pollution) and climatic (low precipitation and high temperature in summertime) conditions. By analysing different monitoring methods that assess the current state of land and vegetation patterns, we can better understand the ecological dynamics driving rangeland degradation and identify key indicators of ecosystem health.

Additionally, this approach considers the impact of human activities, such as grazing practices, land use changes, and socioeconomic factors (land use and availability of labour), on rangeland degradation. By integrating socioeconomic data with environmental assessments, we can develop more comprehensive management strategies that address both environmental and human dimensions.

2.1 Field study in Iceland

Study area.

Fieldwork was conducted in three GróLind monitoring plots near Reykjavík (Fig 1). Two plots (GL1112 and GL1065) are located in sparsely vegetated gravel (Icelandic habitat type Eyðimelavist), while one plot (GL171) is situated in a common-cotton grass fen (Icelandic habitat type Brokflóavist).

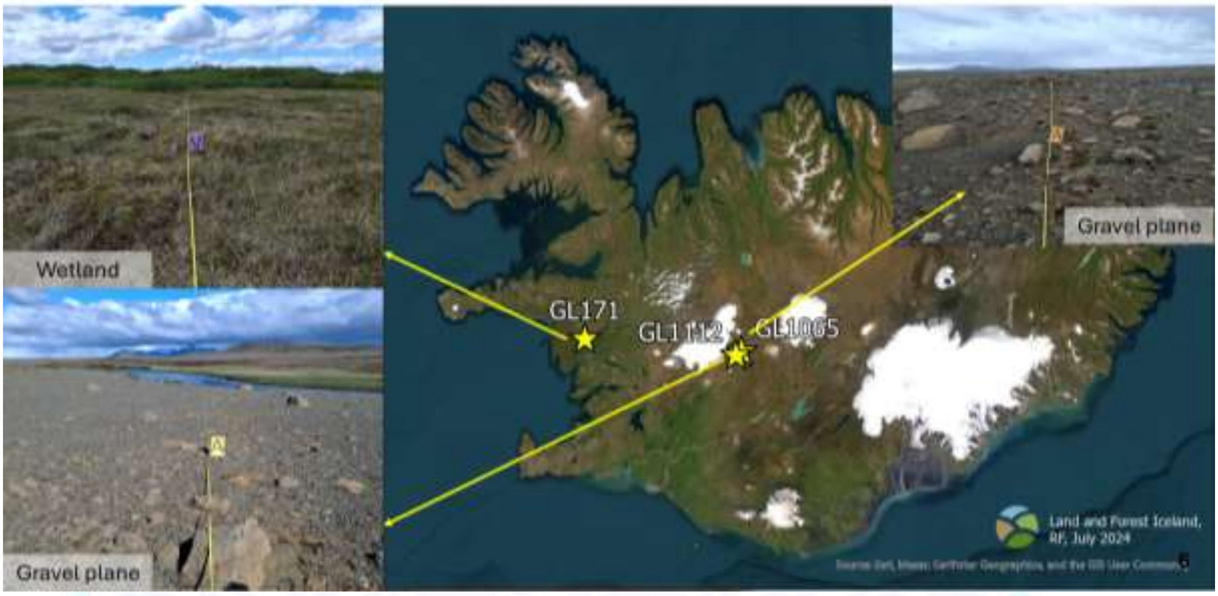
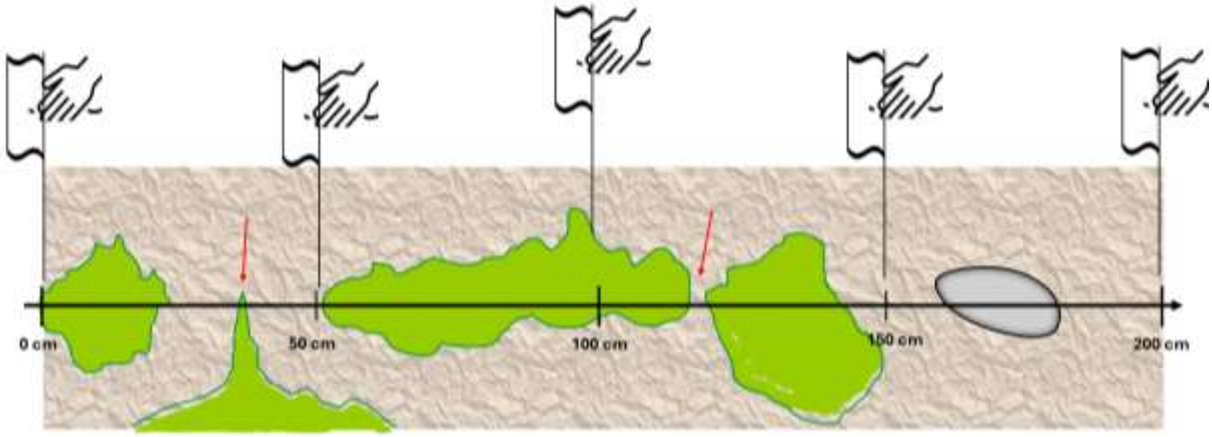


Figure 1. The research plots visited are marked with yellow stars. Pictures taken from the south point of the research plots are indicated with red arrows. The pictures are taken at a height of 150 cm and about 1/3 of the picture shows the horizon.

Methods

Over two days, data collection methods were demonstrated by GróLind project team members. There are several methods used in the GróLind project but here two methods, line point intercept and gap intercept, were studied. GróLind categorizes Iceland's landscape into different ecological habitats for vegetation and soil assessment. The entire plot measures 50 m x 50 m, creating a square monitoring area of 2500 m^2. Two main transects, 50 m each, are established within the plot: one running North-South (N-S) and the other running East-West (W-E,). These transects intersect at the centre of the plot, forming a cross (Finnsdóttir et al. 2023), Along these transects, the line point intercept method was employed to obtain data on functional groups such as bryophytes, forbs, lichens, and shrubs (Finnsdóttir et al. 2023).

The field crew followed the following steps during the Line-Point-Intercept measurement. A measuring pin is randomly placed along the transect at regular (50 cm) intervals, starting at 0 cm and ending at 50 m. The vegetation group that directly touches the measuring pin is recorded from the top down, ending with the surface (Fig 2).



0cm- mosses
50cm – Open soil
100 cm – 1 Trees and shrubs 2 Rooted litter 3 Bryophytes (mosses)
150 cm – open soil
200 cm- open soil

Figure 2. The Line-point intercept method in GróLind measures the proportion of the soil surface that is covered by different functional groups of vascular plants, as well as rocks, litter, mosses, and lichens. Total cover is the proportion of the soil surface that is covered by vascular plant parts, litter, rocks larger than 5 cm in diameter, mosses, and lichens.

Vegetation height and soil depth is measured (at 2 m intervals along the transect), species inventory of all vascular species as well as some groups or species of mosses and lichen (Fig 3).

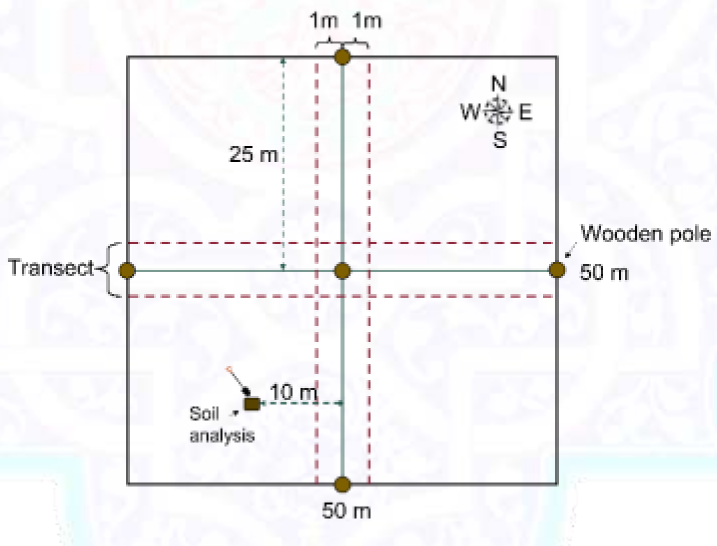


Figure 3. Schematic diagram of a monitoring plot, seen from the air. The plot is 50 x 50 m in size, but most measurements are made on 50 m long transects (green lines) and their location is marked with wooden poles, while at the southern point is a pole marked with a plot number. The dotted lines mark the area where the species list is made (1 m from the tape measure in both directions). A soil profile is dug 10 m north and 10 steps west from the south point.

Gap measurement involves measuring gaps in vegetation cover, open soil, vegetation, and rocks along the transect were catalogued. Data collection starting from 0 to 50 meters along these lines. The minimal gap length was 10 cm. These measurements were taken along the transect using measuring tapes (Fig 4).

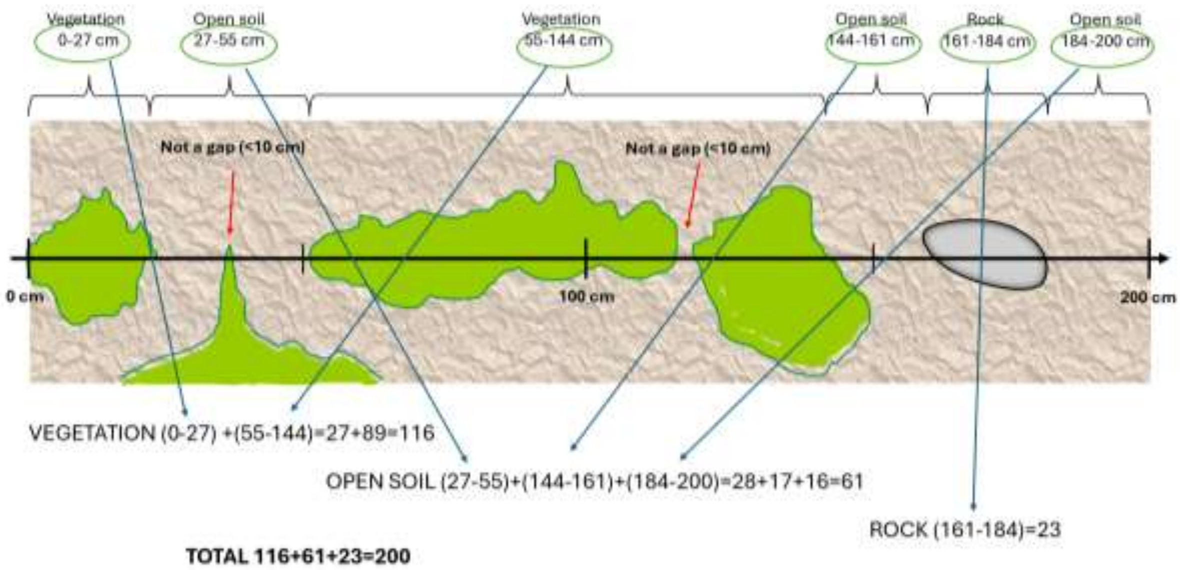


Figure 4. Schematic diagram of gap measurements, as seen from the air. Only the surface below the tape measure is considered. Start recording the table type that is below the tape measure at 0 cm and record where that interval ends, here Vegetation 0 -27 cm. Next comes exposed soil, 27-55 cm etc. Surface models under 10 cm are not included. For example, there is a small amount of vegetation in the range 27-55 but not a wide enough range to change the y surface type class. This continues until the last interval ends at 5000 cm.

Photos were taken of each transect (N, S, W, E) and the entire plot from the south and east ends. A small pit was dug to examine soil texture and layers. Several qualitative methods were employed to assess the state of the plot, including identifying the type and severity of soil erosion, determining the habitat type of the plot, and estimating vegetation cover percentage. If the plot was less than 80% vegetated, the open soil and rocks were divided into size categories (sand, pebbles, small rocks, and bigger rocks). The dominant vascular species were identified, noting the presence of any alien or ecologically important species, and assessing the cover of species that are very palatable or unpalatable for sheep (Finnsdóttir et al. 2023).

2.2 Field study in Uzbekistan

Study area.

The Kyzylkum desert in Navoi is an area of more than 300,000 km square between the Amu Darya and Syr Darya. Kyzylkum district is the most extensive of the botanical and geographical districts of Uzbekistan, it covers the entire territory of the

Kyzylkum desert. More than 48% of the total area of the Republic of Uzbekistan, 21.1 million hectares are occupied by natural rangelands. These natural grasslands have different distributions across regions. The regions with the most common natural pastures include Navoi, the Republic of Karakalpakstan and Bukhara regions, they account for 74% of the total rangeland area in the republic (Gaevskaya and Salmanov 1975).

The Kyzylkum region is diverse in its geological structure, consisting of plains, residual mountains, and depressions between them. Most of the Kyzylkum desert is occupied by sandy plains with an absolute height of 200 m. Most of the plains are covered with landforms - sand dunes, and barrens. Sand-dunes and sandy loams are strengthened by plants. There are relatively few dunes, and they are mainly located along the beach of the Amu Darya, around wells. Barrens are found in depressions between the marsh sands, in the spring they are filled with water, and in the summer, when the water dries up, they become barren. In the central part of the Kyzylkum desert there are low mountains. The most important of them: Kulyuktov (785 m), Etimtov (511 m), Tomditov (974 m), Ovminzatov (695 m), Bokantov (764 m), Mount Sultan-Uvays (473 m). Among these mountains there are swamps such as Mingbulok, Karakhotin, Mullali, Ayakogitma. In these depressions there are salt marshes, barrens, and sands (Zakirov 1971).

Vegetation mainly consists of ephemerals and ephemeroids. The vegetation of the sandy desert consists of specialized shrubby psammophytes, perennial, annual and monocarpic ephemeral grasses, the cover is open, the groups are mobile. As a result of long-term rainfed farming in most of these territories, the original natural vegetation cover has changed and been replaced by other, non-typical species, including less edible, harmful ones (*Peganum harmala* L, *Tribulus macropterus* Boiss, *Leontice eversmannii* Bunge) which are interchangeable with such species. The basis of the palatable plants covers are sedge (*Carex physodes* M. Bieb) and bulbous bluegrass (*Poa bulbosa* L). Also, the majority of the vegetation cover is occupied by such fast growing species as resinous cousinia (*Cousinia resinosa* Juz) and rolled salsify (*Tragopogon conduplicatus* S. A. Nikitin). In such favourable climatic conditions, downy brome (*Anisantha tectorum* L), (*astragalus villosissimus* Bunge), strigosella grandiflora Bunge (*S. turkestanica* Litv) and other species are widespread. Plain, hilly, cumulus, ridge, dune sands in combination with clayey sand and saline depressions (Tuvalov 2023).

In addition, global climate warming is having a strongly negative impact on the rangeland zones of Uzbekistan. The climate in the Kyzylkum pastures is sharply continental, with hot summers (average temperature in July from 27 °C to 29 °C, with a maximum of +50 °C) and relatively cold winters (from 0 °C to –10 °C in January).

The annual precipitation is very low, from 100 mm to 200 mm, especially which falls in winter and spring. (Dan 2023).

Methods

The research was conducted during the spring (17-20 may) and autumn (September 1-3) season of 2022 in the Kyzylkum desert.

Table 1. As part of the work, eight complete geobotanical descriptions with precise GPS reference were completed. Below the collection points of the Kyzylkum district, Navoiy region.

Name of territory	North	East
Eltoy	N 41.13’04.0	E66.03’16.7
(Yangikuduk)	N 41.14’12.3	E66.04’22.6
Eltoy	N 40.54’50.2	E65.31’27.0
(Yangikuduk)	N 40.29’49.2	E65.01’20.1
Yangigazgan	N 40.35’03.9	E65.14’50.7
Zafarobod	N 40.81’53.9	E65.41’44.9
Sarjal (1)	N 40.46’53.9	E64.51’44.9
Sarjal (2)	N 40.40’04.3	E64.53’47.0
Tukkizkhura		
Bukanoy		

Figure 7. Map of the research area in the territory of the Navoiy region, Uzbekistan

During the research, eight areas of rangelands in the Kyzylkum desert were identified (selected for distance from wells) for geobotanical description (Table 1, Figure 7). For each area, their geographic location and elevation above sea level determined using a Garmin GPS navigator. The selected rangeland areas were characterized by the presence of different feed loads and crisis levels (which is no plants, or like degraded land) of vegetation cover. The selected research areas differ from each other not only in their intended purpose but also in their natural conditions, in particular, soil conditions and vegetation cover. Such a difference in the study areas allows for a deeper study of the connections between plant species of the phytocenosis with natural and anthropogenic factors of different levels and the patterns of their change within each research area the soil type was determined into one of five groups (sandy desert, gypsum, barren soil, brown semi-desert and salted) based on description in Butskov (1961).

A vascular plant species list was made for each research area and subjectively determined if the species was dominant in the region and if it was more, less, or moderately distributed. Plant identification was based on “Flora of Uzbekistan” (1941-1962) and Shomurodov, Khasanov (2014) were used. For species that were not identified in the field, specimens were taken and identified by specialists. The list of plant species characteristic and found in the studied desert pasture communities was compiled according to the system of Takhtadzhyan A. L. (1987). The list of species of research areas includes thirty-nine species of higher plants belonging to thirty genera and fifteen families (Fig 8).

3. RESULTS and DISCUSSION

3.1 Line-point intercept

The Line-point intercept methodology utilized in GróLind quantifies the extent of the soil surface that is occupied by various functional groups of vascular flora, alongside substrates such as rocks, litter, mosses, and lichens. Total cover refers to the ratio of the soil surface that is occupied by parts of vascular plants, litter, rocks exceeding 5 cm in diameter, mosses, and lichens. Total cover exhibits a positive correlation with soil and site stability as well as hydrological functionality. It serves to shield the soil surface from the impact of raindrops, thereby mitigating the detachment of soil particles and the physical crusting of the soil surface. Furthermore, an increased cover typically implies a greater number of impediments to the flow of water (Anderson 1974).

Basal and canopy (foliar) cover serve as more sensitive metrics of biotic integrity. These indicators are more intimately associated with production, energy dynamics, and nutrient cycling, as they exclude rock cover unlike total cover. Basal cover is defined as the area occupied by the bases of plants. It is generally regarded as a more reliable long-term indicator compared to canopy cover, owing to its reduced susceptibility to seasonal growth variations, drought, grazing, or other transient disturbances (Morgan 1986).

In regions endowed with the capacity to sustain perennial grassland, an augmentation in basal cover resulting from a shift in species composition frequently (though not invariably) signifies an enhancement in biotic integrity. This phenomenon occurs because perennial grasses typically exhibit a greater ground coverage at their base in contrast to shrubs (Anderson 1974).

Perennial grasses exhibit a marked resilience to specific ecological disturbances, such as herbivory, which contributes to the preservation or enhancement of the overall ecosystem health. In contrast, cool-season bunchgrasses increase resistance and resilience through their varied reproductive strategies, notably their proficiency in seed production (Mangione 2001).

Furthermore, they enhance resistance and resilience by exhibiting adaptability to a broader spectrum of climatic conditions, particularly due to their heightened efficiency in cooler temperature regimes (Benkobi 1986).

Canopy (foliar) cover is frequently used as an indicator of alterations in plant community composition. Nevertheless, due to its inherent variability, it is imperative that data be compared over multiple years while considering annual climatic fluctuations. For such comparisons, it is essential to employ a consistent methodological approach. In this framework, canopy cover pertains to the spatial area physically occupied by plant structures (leaf, stem, flower, etc.) (Morgan 1986).

A plethora of additional indicators can be extrapolated from Line-point intercept data. One notable indicator is the minimum estimate of species richness, defined as the aggregate number of species identified within a given plot, although this methodology necessitates careful application. Line-point intercept generally yields the most conservative estimate of species richness, frequently overlooking species with less than 5% cover. For more precise evaluations of species richness, nested plot methodologies are advocated (Anderson 1974).

The presence of dead and decomposing vegetation exerts a beneficial influence on canopy (foliar) cover by safeguarding the soil surface. Nevertheless, a pronounced increase in standing dead cover may serve as a signal of elevated mortality rates, decreased decomposition rates, decreased fire frequency, or shifts in grazing pressure, all of which are pertinent to the integrity of biological communities. The ratio of dead canopy intercepts serves to quantify the extent of dead and decadent vegetation associated with a particular species (Morgan 1986).

The prevalence of invasive plant cover constitutes a critical measure of ecological transformation, consistently correlating with a deterioration in biotic integrity. The invasion of exotic species frequently results in diminished soil and site stability, as well as compromised hydrological functionality—effects that are corroborated by additional indicators such as woody plant cover, which tends to rise in conjunction with the increasing dominance of invasive species (Herrick et al. 2005).

Figure 9and 9b compares the line point intercept results of two different monitoring plots, GL1112, GL1065 and GL171, with the various LPI categories represented by the letters on the x-axis.

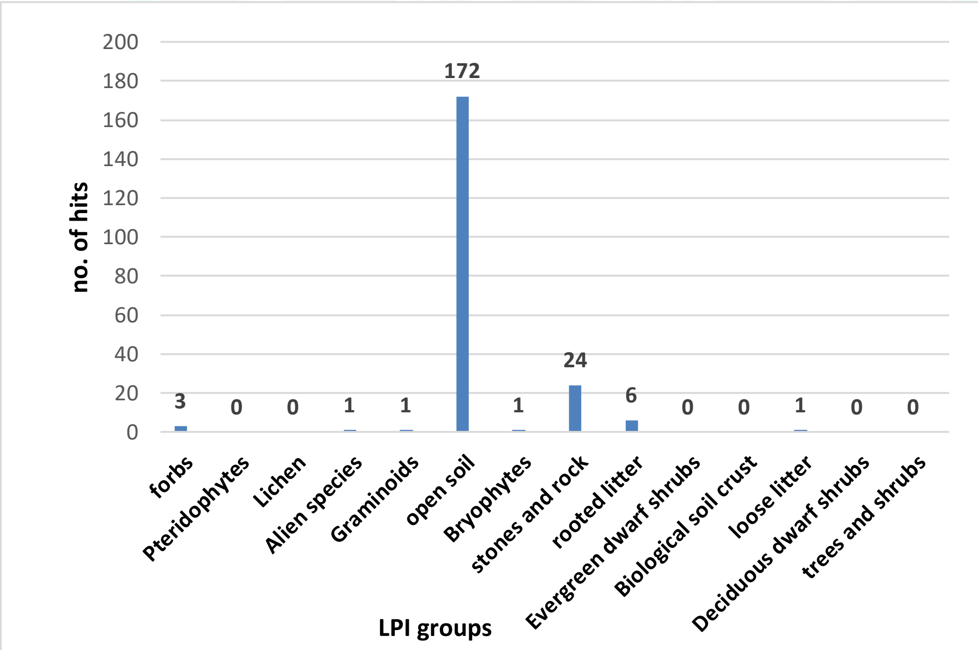


Figure 9a. Line point intercept results from monitoring plot GL 1112 and GL1065 (Gravel plane) almost the result was the same in both areas, so it was added together. In these plots open soil has the main abundance (172 hits) as well as stones and rocks (24 hits).

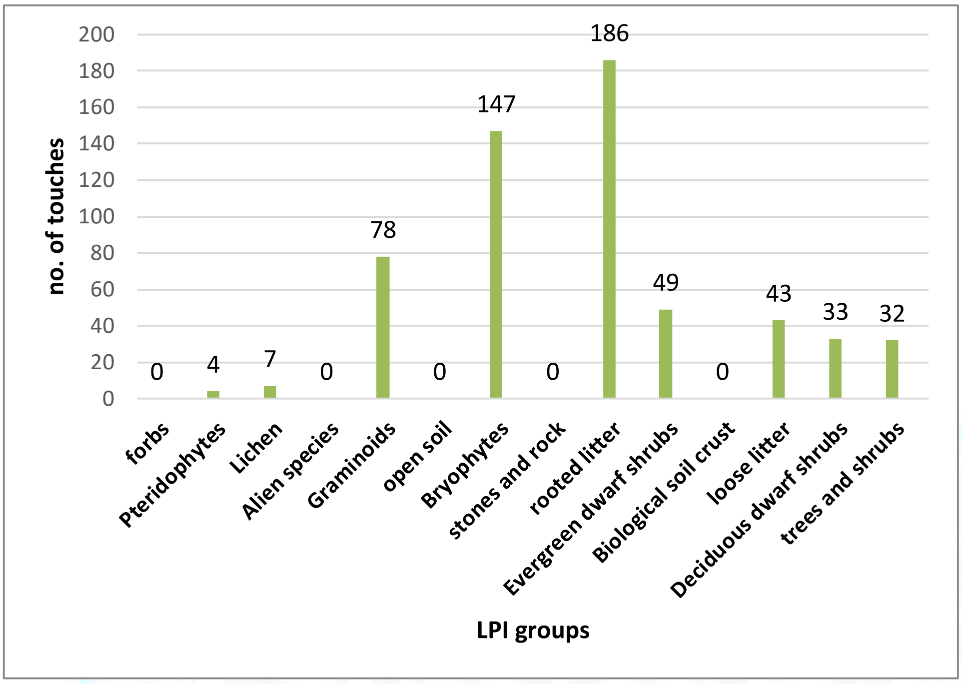


Figure 9b. Line point intercept results from monitoring plot GL 171 (Wetland). In this plot there was a more variation in ground cover, with hits distributed among categories. Rooted litter has the main abundance (186 hits) as well as Bryophytes (147 hits).

3.2 Gap intercept

The spatial configuration of vegetation exhibits a correlation with soil stability, site integrity, hydrological functionality, and overall biotic health. The Canopy Gap intercept methodology does not facilitate a direct assessment of spatial configuration; however, it does furnish insights regarding the degree to which plant coverage is either consolidated (resulting in a limited number of extensive gaps) or dispersed (resulting in numerous smaller gaps). A diminution in total plant canopy coverage typically, though not universally, results in an expansion of the area encompassed by larger gaps. The inter-plant distances (basal gaps) tend to increase when plant populations exhibit greater aggregation and when basal coverage decreases (as observed when shrub species supplant grass species). The ratio of line coverage occupied by canopy gaps exceeding a specified length (for instance, 50 cm) serves as a pertinent indicator. Canopy gaps have significant implications for soil erosion, hydrological processes, and biotic integrity. The extent of area occupied by large gaps can exhibit considerable variability. This indicator may also fluctuate across different sites possessing identical total canopy coverage (as quantified by the Line-point intercept methodology), contingent upon the arrangement of the vegetation (Anderson 1974). The vulnerability of disturbed soil to wind erosion is influenced by the velocity of the wind at the soil surface. Wind speeds tend to be elevated in larger gaps compared to smaller ones, due to the wind-reducing effects of vegetation. In typical desert grassland ecosystems, the phenomenon of wind-induced soil redistribution from a disturbed surface is discernible when the gap diameter—the distance separating vegetation patches—exceeds approximately 50 cm (20 inches) (Herrick et al. 2017).

The provided image shows two pie charts comparing the distribution of land cover types (open soil, vegetation, and rocks) at two different sites (GL1112, GL1065 and GL171) in a South-North (S-N) and West-East (W-E) orientation. (Fig 10).

Figure 10. Percentage distribution of land cover types based on gap measurements on GL1112, GL1065 and GL171. GL1112, GL1065 (gravel plane) are predominantly covered with open soil (89%), with a smaller proportion of rocks (9%) and minimal vegetation (2%).GL 171 (wetland) is entirely covered with vegetation (100%), with no open soil or rocks present.

4. CONCLUSIONS

While Uzbekistan's methods are still developing and primarily ground - based, Iceland uses a sophisticated mix of technology and long-term data analysis. Mongolia, on the other hand, blends traditional knowledge with modern monitoring techniques, making it a unique approach suited to its specific context. Each country's methods reflect their environmental conditions, available resources, and management goals.

The profound significance of rangelands on a global scale, in terms of providing essential ecosystem services like food, water, and livelihoods, especially for disadvantaged populations, is of utmost importance. This is particularly evident in areas where pastoral livestock husbandry dominates land usage, and where rangelands are highly susceptible to deterioration. Illustrations from Mongolia and Uzbekistan, as well as programs like Iceland's GróLind monitoring initiative, showcase varied strategies for rangeland management and the obstacles encountered in diverse climatic and socio-economic settings.

The degradation of rangelands, propelled by factors such as climate variations, excessive grazing, and inadequate land management policies, presents a pressing challenge demanding immediate and concerted actions. This decline has widespread repercussions, including diminished biodiversity, reduced productivity, and hastened desertification, all of which pose risks to both ecological sustainability and the well-being of millions reliant on these territories.The observed trends in land degradation in Uzbekistan carry significant ramifications for agriculture, biodiversity, and the welfare of individuals dependent on the land. Addressing these issues requires a multifaceted approach encompassing improved land management, restoration endeavours, and global partnerships to ensure sustainable growth and environmental conservation. Participating in field work with the GróLind team around Reykjavik offered invaluable practical experience. GróLind an Icelandic programme focused on sustainable Land Management, employed several methods monitor rangeland health. By joining their field workers hands on experience was gained with various tools and techniques used in monitoring.

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