FROM ROOTS TO RICHES:

PRIORITY POLICY AND INVESTMENT DECISIONS FOR GRASSLANDS AND SAVANNAHS

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EXECUTIVE SUMMARY

Grasslands are a huge storehouse of biodiversity and ecosystem services, supporting global food security along with the livelihoods of a multitude of human cultures and societies

Purpose of report: Clarifying and communicating the values of grasslands is essential to catalysing increased conservation, restoration and sustainable management. Grasslands and savannahs face significant and widespread threats from multiple fronts and are an underacknowledged ecosystem in the minds and imaginations of people around the world. The report reflects a growing recognition and commitment to grassland and savannah conservation within WWF and partners, due to their critical roles in food security, biodiversity, ecosystem services and human cultures. It contributes to momentum building towards the International Year of Rangelands and Pastoralists and the next Conference of Parties of the UN Convention to Combat Desertification (UNCCD) in Mongolia, both in 2026. This report aims to help governments to develop ambitious yet realistic conservation strategies for these critical ecosystems and inform private sector initiatives and finance.

Grasslands and savannahs are at a critical point in their conservation – while we have lost a tremendous amount, there is still much to be saved. The report considers the grassland biome economically, ecologically, and socially, providing recommendations to secure and enhance those values. It suggests definitions of key terms to address the ongoing confusion regarding terms used to describe grasslands and provides a new methodology for identifying priority grasslands for action, from both ecological and social perspectives. Finally, the report highlights steps to support sustainable grassland management around the world and gives a call for action to improve the status of grasslands worldwide.

Background: Grasslands and savannahs are arguably the world's largest terrestrial biome, generally said to cover up to 40% of land area, although definitional issues and fluctuations between grassland and forest make precise figures hard to calculate. The biome is a huge storehouse of biodiversity and ecosystem services, supporting global food security along with the livelihoods of a multitude of human cultures and societies, including many pastoralist groups still often following nomadic and transhumant lifestyles. Yet it is also the ecosystem that has been most dramatically transformed.

Global status of grasslands: Grasslands are one of the most at-risk ecosystems and threats are pervasive, complex and interconnected, exacerbated by poor protection and inappropriate or absent management. Globally, less than 10% of remaining grasslands are in protected areas. Ninety percent of temperate grasslands have already been converted to agriculture and urban areas, and half of remaining grasslands are degraded to some extent, with massive implications for food security, economies, climate mitigation and adaptation efforts, biodiversity and culture.

Global dependency on healthy grasslands: Grasslands provide a range of provisioning, regulating, cultural and supporting services, including food and water security, health, disaster risk reduction, climate change mitigation, cultural and livelihood values, recreational and spiritual values. Most of the world's grasslands are used for livestock production, thus playing a critical role in food security and rural livelihoods. The values of grasslands have often been underestimated compared with other biomes, such as forest, wetlands and coral reefs.

What are the economic values of grasslands and savannahs? Economic benefits from grassland and savannah ecosystem services are still inadequately studied, and only a tiny percentage of studies include economic analysis. Many focus narrowly on provisioning services, particularly agricultural outputs, and ignore other ecosystem and cultural services, thus prioritising private market value over services with broader public value. Additionally, many economic evaluation methods are criticised for taking an overly narrow, short-term perspective. The largest economic values identified come from regulating services. Much of the value of grasslands is now presented in terms of carbon sequestration and storage, whereas their actual value is far more extensive. More numbers are currently available for what we have lost. Researchers estimate annual costs of rangeland degradation in Central Asia averaged US$4.6 billion each year between 2001 and 2009, while land degradation negatively impacted livestock productivity globally by US$6.8/year (2007 prices) from 2001 to 2011.

Threats to grasslands and savannahs and the implications: Grassland and savannah ecosystems are amongst the most heavily converted because of their suitability for food production and settlement. Many grasslands are substantially degraded, which diminishes their ecosystem services. Grassland conversion is driven by agricultural expansion, urbanisation and afforestation. Native grasslands are being converted to produce soy, oil palm, cotton, wood pulp, livestock feed and biofuels, and an increase in future conversion could be triggered by new

transportation and energy infrastructure, combined with a growing human population. Grassland degradation is driven by incompatible grazing regimes, invasive species and pollution, themselves all subject to complex underlying drivers.

The combination of these changes is reducing ecosystem services, directly impacting food and water security and disaster risk reduction, along with many cultural services. Grassland conversion and degradation drive soil erosion; the impact of soil erosion on agricultural productivity at global scale is estimated at about US$8 billion and could present an acute challenge to food security in vulnerable regions in Africa and in the tropics. Healthy grasslands play a crucial role in regulating the hydrological cycle, and their degradation is leading to increased fluctuations in water availability.

Priority grassland habitats: While we must conserve and reverse degradation of grasslands and savannahs worldwide, some grassland ecosystems are higher priority because of their outsized role in protecting certain species, ecosystem services, food security and/or dependent and threatened human cultures. While acknowledging the critical importance of food security, we have developed a tool to prioritise grasslands and savannahs from a conservation perspective based on wildlife and ecosystem services and considering degree of threat.

Pathways to address conversion and degradation: Addressing current problems of grassland degradation and loss must confront the fact that different actors have very different visions for what constitutes a healthy biome, a problem made worse by the lack of systematic species datasets across grasslands. From a sustainable development perspective, two complementary approaches are needed: 1) working across land management types to incorporate wider environmental considerations into existing systems and 2) using a planned and negotiated approach to supply a full range of goods and services, which includes areas set aside to prioritise different needs such as food production, ecosystem services and biodiversity. This is reflected in the Protect, Manage, Restore approach that prioritises protection of existing grasslands, followed by improved management practices, and finally restoration of degraded areas. This approach should be grounded in participatory governance that reflects the diverse ecological, cultural and production values of grasslands.

Policy recommendations: Advancing meaningful solutions will require a judicious mix of legislation and policies, including private sector policies, often coupled with financial incentives and capacity building at a local level. Information is still often lacking for essential analyses, on baseline composition and status of grasslands and on many details of sustainable management and restoration. Below is a list of some high-level policy recommendations; many are aimed at governments, some at industry and broader civil society:

Support the national implementation of UNCCD Land Degradation Neutrality commitments to conserve and restore grasslands and savannahs and the recent advances targeting rangelands and pastoralism.

Consider grasslands in an integrated manner across all three Rio conventions (UNCCD, UNFCCC and the CBD) to break silos and maximise effectiveness. Pursue and secure long-term funding for protected areas and invest in baseline assessments, mapping and monitoring to identify key areas for targeted protection. Address counterproductive policies and investments that contribute to land use change and degradation.

Address complex problems of both overgrazing and under-grazing, including through removal of perverse policies and incentives where necessary. Advance conservation policies and programmes to support more sustainable grazing while recognising the rights of Indigenous peoples, and local communities.

Remove perverse incentives for afforestation, particularly under climate mitigation initiatives.

Develop comprehensive programmes to address invasive species in grassland in cooperation with local users.

Support pastoralist communities, their culture and production systems, working with them to achieve comprehensive and participatory land use planning integrating nomadic herding, transhumance and mobile pastoralism with other land uses such as tourism and conservation.

Recognise and enable pastoral mobility and implement capacity building support for Indigenous peoples, local communities, farmers and herders to upgrade and improve sustainable livestock grazing and management.

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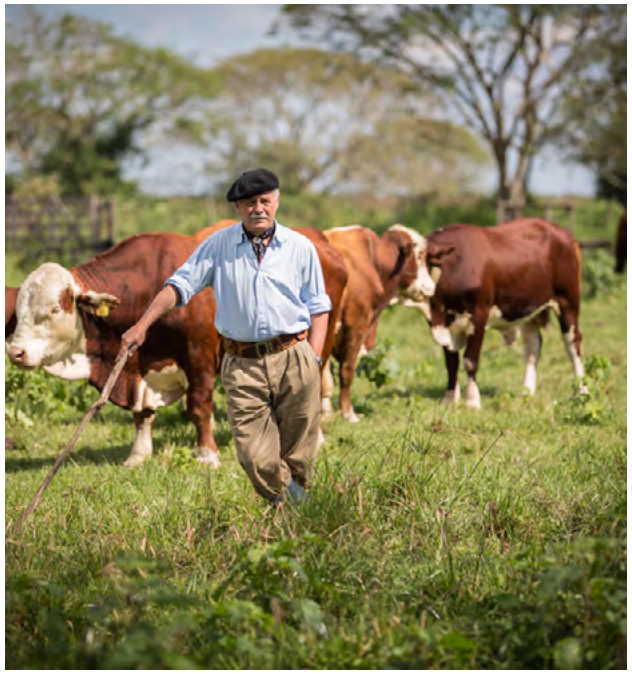

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Recognise grasslands as important and stable carbon stores and afford them greater priority in climate negotiations (UNFCCC) and inclusion into Nationally Determined Contributions (NDCs). Assess the economic value and benefits of ecosystem services delivered through a shift to more sustainable grazing practices.

Facilitate research, monitoring and implementation of restoration projects on degraded grasslands, to recover biodiversity, ecosystem services and opportunities for sustainable use. Develop strategies to address research gaps in grassland restoration, with a focus on the dynamics and adaptive requirements of different grasslands.

Restore large, wild herds moving over extensive, connected and diverse landscapes (UN Decade on Ecosystem Restoration) and connect their management to local populations. When appropriate, develop market opportunities for nature-based tourism in rewilded grassland landscapes.

Prioritise investments for highest value outcomes and encourage innovation: Payments for results over practices similarly can make optimal use of resources while giving farmers freedom to choose their practices and be innovative solution finders.

Adopt cohesive national policy frameworks and a robust ecosystem classification system to successfully conserve and restore grasslands and monitor grassland ecosystem trends.

Increase investment in tracking conversion. Regional monitoring programmes can both identify remaining intact grasslands/habitat so that resources can be directed to those areas and identify accountability where conversion has occurred.

Dramatically expand more direct-to-producer, -producer organisation, and -producer cooperative financing programmes, prioritising sustainable land management.

Prioritise peer-to-peer networking and system knowledge transfer, as well as financial investment in technology and capacity building to support their benefits at scale.

GRASSLANDS AND SAVANNAHS

INTRODUCTION

Key points:

- Grasslands and savannahs make up one of the world's largest terrestrial biomes.
- Despite widespread degradation and conversion, it is still a critical source of biodiversity, ecosystem services, climate resilience and livelihoods.
- There is confusion about the terms used to describe grasslands; we aim to bring some clarity.

Policy entry point:

- Grasslands require far higher priority in national and international debates on food security, climate change and biodiversity.

Grasslands and savannahs are arguably the world's largest terrestrial biome, generally said to cover up to 40% of land area.[1] Grasslands are a huge storehouse of biodiversity and ecosystem services. They support global food security along with the livelihoods of many human cultures and societies, including pastoralist groups following nomadic and semi-nomadic lifestyles.[2] Yet grasslands are also the ecosystem that has been most dramatically transformed.[3,4]

Huge areas of former grassland are unrecognisable under crops or intensive livestock, covered by concrete and fragmented by transportation systems and energy facilities. Pollution and invasive species degrade places that at first sight seem to be in good condition, including many protected areas.[5] Most large herds of wild herbivores have been reduced or lost, with knock-on losses of ecosystem services. Long-established grazing and fire regimes that maintained grasslands have disappeared from large areas, often due to settlement and use by more powerful actors. Increased drought impacts many pastoralist systems.[6] Loss of livestock or native grazers and browsers has encouraged woodland encroachment in places. Elsewhere, rising human populations, climate change, perverse incentives or changing expectations encourage increased livestock numbers, which degrade grassland. Grasslands have also tended to receive less attention from conservation organisations than forests, so problems have tended to go unnoticed.[7]

Despite the challenges, there is a great deal that can still be saved or lost: many pastoralist systems exist, many grassland and savannah ecosystems survive, albeit often degraded, and are ripe for conservation or restoration.

The following report provides an overview of the importance, status and futures of grassland and savannah ecosystems. We identify their significance and values and highlight where more information is needed to build a richer picture of how grasslands and humanity support each other. We summarise threats facing the biome and explain what we could do to address these.

Grassland and savannah are often poorly represented in national accounting systems and ecosystem service valuations. Conclusive statistics on their extent are unavailable, both due to differences between datasets and because of debate about where a grassland ecosystem starts and ends in relation to forest and woodland, drylands, deserts and tundra. According to the Food and Agriculture Organization of the United Nations (FAO), everything over half a hectare with trees higher than 5 metres and 10% or more canopy cover is a forest,[8] whereas grassland experts say that any ecosystem with an understorey of light-loving grassland species is grassland, irrespective of trees. Ecosystems like the Cerrado of Brazil and the miombo of Tanzania are classified differently, depending on who is doing the classification and why. This hampers natural resource management, policy making and conservation effectiveness. Nonetheless, some important compilations have been done and the technical possibilities are expanding all the time.[9] One well respected estimate is that there was 28 million km^2 of pasture globally in the year 2000,[10] and different grassland types have been mapped around the world.[11]

Selecting a terminology and set of definitions is difficult when trying to integrate multiple viewpoints, although the need is recognised.[12] Some people refer to all grassland as rangeland to focus on rural livelihoods and the outsized role of grazing as an ecosystem management tool in grasslands around the world, while others confine rangeland to places where livestock are managed. Terms like old-growth grassland[13] describe the most natural systems, other attempts focus on grazing lands,[14] while some ecologists feel that all grasslands have been so altered by humans that a better term is "semi-natural grasslands".[15] Inconsistent definitions across classification systems contribute to misalignment in conservation status assessments, policy frameworks, and eligibility for financing instruments. Box 1 below gives some definitions as applied in this report, drawing on earlier discussions between many partners,[16] so all readers start on the same page. They do not represent the last word on this issue.

In the report, for the sake of brevity we often simply refer to "grassland" as a catchall phrase.

The report looks at the values of grasslands, identifying a typology of ecosystem services

BOX 1: DEFINITIONS OF GRASSLAND, SAVANNAH AND RANGELANDS

Grassland and savannah: *Land on which the vegetation comprises predominantly indigenous unsown grasses, grass-like plants, forbs or shrubs.*
Rangeland: describes a state of management rather than a particular ecosystem type. *A working definition is: land used to raise livestock alongside wildlife in an extensive system with a cultural and identity connection to pastoralism.*

The goal of this report

Understanding the values of grasslands to human life is essential in making the case for conservation, restoration and sustainable management. We have provided quantifiable values where available and reliable, including economic values, but also report on the qualitative values of the biome. These often carry more weight in real-world political and programmatic decisions.

Grasslands and savannahs face some "wicked problems", so-called because they emerge from multiple factors, are ecologically and socially complex and fairly intractable.[17] Addressing these, which include conversion (for a variety of purposes), unsustainable grazing pressure and pollution, forms an important part of the text.

The report reflects a growing commitment to grassland and savannah conservation within WWF and partners, due to their critical roles in food security, biodiversity, climate change mitigation and adaptation, ecosystem services and human cultures. It contributes to the momentum building towards the International Year of Rangelands and Pastoralists (IYRP) and the 17th Conference of Parties (COP) of the UN Convention to Combat Desertification (UNCCD) in Mongolia, both in 2026. It draws on previous work, including an online dialogue platform,[18] which meets regularly to discuss relevant issues. It builds on the knowledge and evidence base developed by the UNCCD related to Land Degradation Neutrality[19] and the policy-relevant information contained in successive *Global Land Outlook* (GLO) reports including the GLO *Thematic Report on Rangelands and Pastoralists*,[20] which underpinned the first UNCCD decision on rangelands and pastoralists in 2024.

We hope that the conclusions help governments to develop ambitious yet realistic conservation strategies for these critical ecosystems and inform private sector initiatives and finance. The conservation strategies should also support international initiatives such as the Kunming-Montreal Global Biodiversity Framework (GBF) from the Convention on Biological Diversity, the actions of the UN Framework Convention on Climate Change (UNFCCC), the UNCCD's Land Degradation Neutrality targets, UN Decade on Ecosystem Restoration and the Sustainable Development Goals.

The report looks at the values of grasslands, identifying a typology of ecosystem services. Next, the pressures affecting grasslands are described with their underlying causes. The implications are summarised as they relate to biodiversity, other ecosystem services, climate change and to the social benefits that grasslands support. A methodology is described to identify priorities for action, from both ecological and social perspectives. Economic values are explored, in the rare cases where they have been calculated. In a penultimate section, different responses to grassland degradation and loss are described: including protection, sustainable management and restoration. A final section looks at steps to highlight and support sustainable grassland management around the world and gives a call for action to improve the status of grasslands worldwide.

HEALTHY GRASSLANDS AND HUMAN LIFE

Key points:

- Grasslands and savannahs play a critical role in food and water security, disaster risk reduction and human livelihoods and culture.
- Within the biome, diverse, natural grasslands provide the widest variety of ecosystem services.
- A range of provisioning, regulating, cultural and supporting services are summarised.

Policy entry point:

- Policy must more fully recognize the full range of grassland ecosystem services and incorporate the value grassland ecosystem services bring into national strategies for sustainable development.

Natural grasslands are a rich source of ecosystem services, which play a critical role in food and water security and human livelihoods and cultures.[21]

Yet failure to recognise this by government and economic leaders has led to them being widely undervalued in our economic and land management systems. Despite their incredible value, grasslands are often looked down on by policymakers as wasted or open space,[22] which makes them highly vulnerable to conversion to crops or plantations.

Not all grasslands are equal. The quality of a grassland ecosystem is almost as important as its area. Most grasslands are highly transformed. A pasture ploughed up and reseeded with a monoculture of a non-native grass species might still look green, and in agricultural parlance will often be referred to as “improved” in terms of livestock productivity but will only provide a fraction of the wider benefits of a rich, natural grassland. Balancing the needs of food production with those of other societal and planetary needs is one of the great challenges of grassland management. Many – probably most – of the related ecosystem services are reliant on the diverse variety of species that natural grasslands support; some of the world’s highest levels of biodiversity.[23] Upland grasses in Argentina can hold up to 89 plant species a square metre, with numerous associated insects, reptiles, birds and mammals.[24] Grasslands and savannahs are home to huge herds of herbivores and associated predators in sub-Saharan Africa and Central Asia, where they continue to make some of the world’s longest land-based migrations.[25,26]

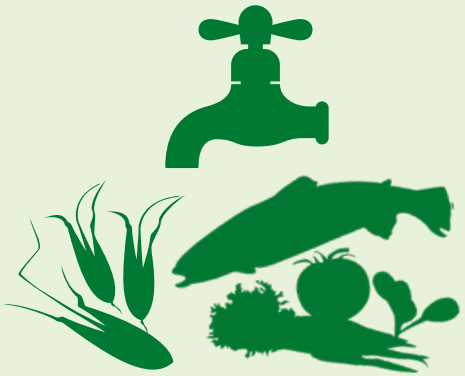
This profusion of life is not just of aesthetic or sentimental appeal. While biodiversity conservation is a moral imperative,[27] biodiversity is also the foundation of grassland ecosystem services. There is compelling evidence that grasslands and savannahs with high biodiversity have greater resilience in the face of environmental change,[28,29] including climate change,[30] and provide a wider range of ecosystem services to benefit human communities.[31] This makes high-diversity grasslands critical assets for nature-based solutions and climate adaptation, particularly in drought-prone regions.

High-diversity grasslands are critical assets for nature-based solutions and climate adaptation, particularly in drought-prone regions

A typology of ecosystem services from grasslands and savannahs

Global food security is dependent on grassland

PROVISIONING SERVICES: GENERALLY, GOODS – FOOD, WATER, MEDICINES, ETC. – THAT HUMANS NEED TO LIVE.



Ecosystem services are the direct and indirect contributions that ecosystems provide for human wellbeing and quality of life. They are often broken down into four main types: *provisioning*, *regulating*, *cultural* and *supporting* services.

All are important although some – particularly cultural services – are valuable in different ways to different individuals and societies. Understanding how people view grasslands is critical to developing conservation policies.

Food security

Global food security is dependent on grassland.[32] While the fact that many grasslands provide ideal conditions for growing crops makes them vulnerable to conversion,[33] grasslands are also important contributors to food security. Most remaining grassland is used for grazing livestock, providing meat and dairy products. If we count the food security benefits from grasslands converted to cropland and cultivated pastures, we must also consider the detrimental cost to other ecosystem services.[34]

Livestock grazing: the most direct contribution to food security is as rangeland for ruminant livestock.[35] The area used for grazing domestic animals accounts for a quarter of all ice-free land, larger than the whole of Africa.[36] Grazing takes three main forms: on large-scale ranches (where livestock may or may not be moved); on smallholdings; and through systems of traditional transhumance where animals are moved periodically, often between seasonal grazing areas. Today, only a minority of livestock graze all their lives, mainly in marginal and arid lands or mountain regions, while most are at some point confined indoors or in feedlots. This requires supplementary food; livestock consume a third of global cereal production, along with significant amounts of agricultural biproduct,[37] which reduces their net benefit to food security. Livestock are culturally and economically important in many regions and can support a range of other ecosystem services.[38,39]

Wild food: perhaps 10 million hunter-gatherers still exist,[40] a significant number on grasslands and savannah. Wild foods are vital for many other people as well,[41] if crops fail or to get over "hungry gaps" when food stores run out and new crops are not ready.[42] Wild meat remains a vital resource for many people in savannahs.[43] Plants are also important[44] and insects can be a critical source of protein.[45] Overexploitation of wild food is a major problem, but wild-collection remains a critical livelihood strategy for many people, especially in marginal environmental or political settings.[46]

Crop wild relatives: play an irreplaceable role in food security, providing the genetic material needed to respond to new diseases and climate change, with most grain species coming from grasslands.[47,48] For example, Aïr and Ténéré National Nature Reserve in Niger harbours genetic resources of several important crops including millet (*Pennisetum glaucum*), barley, wheat and sorghum (*S. aethiopicum*).[49] Almost 30 years ago, the annual global value of crop wild relatives (CWR) in boosting productivity was estimated at US$115 billion.[50] Yet crop wild relatives are often ignored in conservation planning.[51]

Water security

Grasslands support water security[52] through protection of surface[53] and groundwater[54] sources. Vegetation cover helps water penetrate the soil rather than running off, increasing groundwater recharge. Some dryland species also scavenge water from fog.[55] Many communities depend on grasslands for their water, often including people living far from the ecosystem. For example, the Cerrado is considered the "cradle of Brazilian waters" supplying water to 8 out of 12 hydrographic regions.[56] Conversion can reduce available water, e.g., conversion of natural grassland to intensive Ponderosa pine (*Pinus ponderosa*) in the Nebraska Sand Hills in the United States reduced overall groundwater recharge by almost 17%.[57] Targeted restoration can help to reverse losses due to degradation. Research in the Albany Thicket biome in South Africa found that restoring degraded lands increases vegetation cover and thus improves the potential for water infiltration.[58]

REGULATING SERVICES:
ECOSYSTEM SERVICES THAT PROVIDE ENVIRONMENTAL STABILITY, SUCH AS DISASTER RISK REDUCTION, MITIGATION OF CLIMATE CHANGE AND REGULATION OF THE FLOW AND QUALITY OF FRESHWATER.

Health

An estimated 65-80% of the world's population still rely partly or completely on wild plants and animals for medicines,[59] which also have a large commercial value. Globally at least 60% of medicinal plants are gathered from the wild,[60] with an annual value of over US$50 billion.[61] Grasslands are an important source,[62] and sustainable harvesting methods are essential. A well-known example is *Harpagophytum procumbens*,[63] or devil's claw, a member of the sesame family growing in the Kalahari region of Namibia, Botswana and South Africa.[64] The tubers have been used as medicine for centuries. Pharmaceutical studies have measured the efficacy in treating rheumatoid arthritis. Thousands of local harvesters sell tubers as their only source of income.[65] Demand in Namibia led to over-collection and introduction of controlled harvesting and permits,[66] with collection in Bwabwata National Park achieving organic certification through a collaborative project with WWF.[67]

Climate mitigation – storage and sequestration

Despite storing far less carbon per unit area than forests, the vast area of grasslands means they are a major global store,[68] accounting for 25-35% of terrestrial carbon,[69,70,71] and thus helping mitigate climate change.[72] In Tanzania for instance, although miombo woodlands (a savannah) only store 10-20% of the carbon as closed-canopy forest, the huge area of miombo means that it is a more important national carbon store overall.[73] Grassland plant diversity is positively correlated with soil carbon, particularly in warm and arid climates.[74] Up to 90% of grassland carbon is stored below ground in roots and as soil organic carbon (SOC).[75,76,77,78] Grassland is sometimes a more reliable carbon store than forests in high fire risk areas,[79,80] because light grass fires do not release much SOC,[81,82] or destroy soil microorganisms,[83] while intense forest fires can lead to greater emissions overall. Accurate statistics on grassland carbon are hampered by disagreement about where grasslands merge into forests and wetlands[84] and by variations in sequestration and storage between grassland ecosystems.[85,86,] Semi-natural grasslands sequester and store more carbon than modern agricultural landscapes.[87] Protection of SOC is most effective if combined with biodiversity conservation;[88,89] by protecting ancient grassland, restoring degraded grassland and appropriate reseeding.[90,91] Carbon storage is also influenced by the presence of a full complement of herbivores and predators to maintain a healthy grassland ecosystem.[92,93]

Water quality and flow

The quality and regularity of water is as important as the volume available. Healthy grassland protects against flooding because of its greater absorptive capacity and reduction of surface water flow,[94] so that water is released more gradually into streams and rivers. Water flowing through natural grasslands is less contaminated than from farmland or intensive livestock husbandry.[95] Conversely, degradation of grassland, soil erosion and desertification all undermine these services.[96]

Soil stabilisation and desertification control – disaster risk reduction

Maintaining healthy grasslands is an important contributor to disaster preparedness strategies.[97] Disaster risk reduction in grassland ecosystems focuses particularly on issues relating to erosion, desertification, flooding (see above) and drought. Healthy grassland ecosystems reduce soil erosion, dust storms,[98] compaction[99] and desertification,[100] and are more resistant to drought.[101]

Pollination and other agricultural support

Grassland supports wider food production in a variety of ways. The UN Food and Agriculture Organization (FAO) has coined a term: *Biodiversity for Food and Agriculture*, covering soil micro-organisms, beneficial bacteria, predators of pests and many wild and domesticated species.[102] Particularly critical are pollinators.[103] Almost 90% of flowering plant species are pollinated by animals (bees, moths, hummingbirds, etc.)[104] and crops at least partially pollinated by animals produce 35% of our food.[105] Bees are the main pollinators,[106] and most farmers rely on wild species, sometimes also cooperating with local beekeepers. Estimated global values of crop pollination, adjusted for inflation in March 2020, range from US$195 billion to ~US$387 billion annually.[107]

CULTURAL SERVICES:
RANGING FROM HISTORY AND AESTHETICS, THROUGH SPIRITUAL OR SACRED VALUES FOR FAITH GROUPS TO LIVELIHOOD SUPPORT FOR THE MULTITUDE OF HUMAN SOCIETIES THAT EXIST AROUND THE WORLD.

Pastoralism and other traditional grassland cultures

Grasslands and savannahs support a quarter of the world's people, with huge cultural diversity, such as gauchos in South America, nomadic herders in Central Asia, hunter-gatherers on the African plains, ranchers in North America and traditional shepherds in Europe.[108] Grasslands are home to most of the world's 500 million pastoralists[109] and there is a rich store of traditional ecological knowledge related to grassland management.[110] Modernity and intensification of agriculture means that many pastoralist communities' way of life has been threatened and they fear for the future.[111] In light of their cultural importance and the threats they face, 2026 has been designated the International Year of Rangelands and Pastoralists (IYRP).[112] Additionally, many permanently settled farmers and ranchers have deep, multi-generational cultural links to particular grasslands.[113] Any conservation of grasslands and savannahs needs to take careful account of these cultural needs and any conservation strategies developed closely with the people most directly involved.

Recreational values

Wildlife tourism, trophy hunting and adventure holidays in savannah regions of Africa are a major source of foreign exchange for several countries,[114] and demand is growing fast in places like Mongolia, the Pampas of Latin America and on the North American Great Plains. Recreational activities are a major cultural service in European grassland.[115] Grasslands and savannahs have more local recreational benefits as well, for walking, outdoor sports and picnics, which must be balanced against other uses.[116] Global estimates of the economic value of grassland tourism do not exist but the most iconic sites generate large incomes. For example, the Greater Serengeti Ecosystem in Tanzania attracts 300,000 visitors a year, generating US$500 million,[117] while Kruger National Park and surrounding reserves contribute US$370 million a year to South Africa's economy.[118]

Spiritual values, sacred landscapes and aesthetics

Faith-based influences are important both for promoting conservation and as a factor that needs to be included in management.[119] Many grasslands contain sacred natural sites,[120] sacred landscapes,[121] and other important areas for faith groups such as religious buildings and pilgrimage routes. Some are of value only to very local communities, others are places of importance for major faiths.[122] Grasslands supply secular cultural and aesthetic benefits to people, ranging from an appreciation of the landscape through to the many artistic creations that have resulted from an interaction between a writer, painter or musician and a particular place.[123,124]

SUPPORTING SERVICES:
SUPPORTING SERVICES ARE THE BUILDING BLOCKS OF LIFE, THE PROCESSES BY WHICH SOLAR ENERGY IS CAPTURED AND USED, AND MATERIALS ARE CYCLED THROUGH AN ECOSYSTEM.

These include conversion of solar energy through photosynthesis, formation of soil, the weather cycle, circulation of water, the cycling of nutrients and materials through the processes of birth, death, decomposition and the weathering of rocks and other materials. These services are critical and often taken for granted; yet over huge areas of grassland they have already been seriously undermined through their degradation and loss.[125,126]

WHAT ARE THE ECONOMIC VALUES OF GRASSLAND AND SAVANNAH?

Key points:

- Grasslands and savannahs have had relatively little attention from natural resource economists.
- The largest economic values seem to come from regulating services.
- Total economic value (TEV) for grasslands is lower than for many other ecosystems, but estimates are increasing over time as more benefits are being recognised and costed.

Policy entry point:

- Additional research is needed to advance much better understanding of the full economic values of services from grasslands, which are currently under-researched, as well as policies to recognize and support these grassland services.

Economic benefits from grassland and savannah ecosystem services are inadequately studied. Analysis of 646 papers on grassland ecosystem services published in 2023 found only 3% included an economic analysis.[127]

Many focus narrowly on provisioning services, particularly agricultural outputs, and ignore other ecosystem and cultural services, thus prioritising private market value over services with broader public value.[128] Even those studies that focus on wider ecosystem services generally only consider a subset.[129] Questions are increasingly being raised about approaches that only look at provisioning services, notably in a recent report from IPBES, the Intergovernmental Science-Policy Platform on Biodiversity and Economic Services, which examined over 50 evaluation methods and criticised most for taking an overly narrow, short-term perspective.[130]

Nonetheless, some important economic studies exist. In one of the first global studies of the economic values of ecosystem services, comparison of 32 estimates of grassland values produced a mean value (TEV) of Int$2,871*/ha/year in 2012.[131] A more recent meta-study combined 134 primary studies to give an estimated economic value of global grassland ecosystem services, with annual values per hectare varying from US$3,955 for semidesert grassland to US$5,466 for tropical grasslands, with regulating services having the highest value (approximately eight times that of food provision). This suggests an annual economic value of global grasslands of over US$2.8 trillion.[132] A similar compilation and analysis of 1,300 studies found rangelands, natural grasslands and savannah had average values for all services of Int$5,934 per hectare per year, albeit far smaller than most other ecosystems.[133] All these studies are combining multiple values over a huge range of different habitat types and their limitations must be recognised. Furthermore, regulating and cultural values are hard to quantify due to their non-market nature, lack of standardised indicators and geographic variability. It might be noted that the average values have been increasing over time, as more ecosystem services are being recognised and measured.

* An international dollar is a hypothetical unit of currency that has the same purchasing power parity that the US dollar had in the United States at a given point in time.

National or regional studies add to our understanding. A 2012 study in the Czech Republic estimated annual hectarage values of ecosystem services of €1,986-4,498 (US$2,318-5,249) depending on grassland type.[134] Average value for Romanian grasslands was estimated as €1,220/ha (US$1,424).[135] In China, TEV of grasslands was calculated at 10,876 yuan (US$1,484) per hectare per year, with high values for soil fertility and erosion control.[136] Another study found the economic value of grassland ecosystem services in China is as high as 6.22 trillion yuan (equivalent to 6.13% of GDP or 80% of agricultural GDP of China in 2020), mostly from Tibet, Inner Mongolia, Xinjiang and Qinghai and from regulation services.

Most studies remain partial – i.e., only looking at some of the ecosystem services, and focusing on potential losses rather than total values. For example a study in the Brazilian Cerrado estimated climate-related costs of native vegetation clearing at around US$133 billion by 2050, with parallel losses of US$105 billion in agricultural productivity.[137] Similarly, the additional economic value of shifting to extensive grassland management in a region of Switzerland ranged from 150-720 CHF (US$164-786) per hectare per year looking only at carbon, forage and habitat benefits.[138]

While figures for economic value of healthy grassland remain elusive, greater attempts have been made to calculate what we have lost. Researchers estimate that annual costs of rangeland degradation in Central Asia averaged US$4.6 billion between 2001 and 2009,[139] while global costs of land degradation on livestock productivity in 2001-2011 was US$6.8 billion at 2007 prices.[140]

With mitigating climate change a global priority, much of the value of grasslands is now reckoned in terms of carbon sequestration and storage, an issue that had scarcely been recognised when valuation studies began. Here the value depends both on the type and quality of grassland and on its diversity; greater species richness increases economic value.[141] Interestingly, research suggests that increased plant diversity also boosts livestock productivity,[142] suggesting a complementary approach for livestock production and climate mitigation if sustainable management techniques are adopted.

There is clearly a need for far more attention to be paid to valuation of the biome, including valuation studies tailored to regional contexts, which emerges as one of the major recommendations from this report.[143,144]

PRESSURES ON GRASSLANDS AND SAVANNAHS AND THE IMPLICATIONS

Key points:

- Grassland conversion is driven by agricultural expansion and intensification, urbanisation and afforestation.
- Grassland degradation has multiple causes including incompatible grazing regimes, invasive species, and pollution, themselves all subject to complex underlying drivers.
- Degradation factors include loss of native species, changes in fire regimes and climate change.
- These changes all reduce ecosystem services, directly impacting food and water security and disaster risk reduction, along with many cultural services.

Policy entry point:

- Policies are needed to provide more comprehensive responses to the pressures on grasslands created by variable grazing pressure, invasive species, climate change and perverse agricultural and forestry subsidies.

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Grasslands are one of the most at-risk ecosystems and threats are pervasive, complex and interconnected, made worse by poor protection and inappropriate management.[145]

Less than 10% of remaining grasslands are in protected areas; for natural temperate grasslands this drops to 4.6%.[146] Ninety percent of temperate grasslands have been converted to agriculture and urban areas.[147] Grasslands are at risk in Latin America,[148] North America,[149] Africa,[150] Asia,[151] Australasia[152] and Europe.[153] An estimated half of remaining grasslands are degraded.[154] Their loss has implications for food security, economies, climate mitigation and adaptation, biodiversity and culture.[155]

Threats

Conversion and degradation

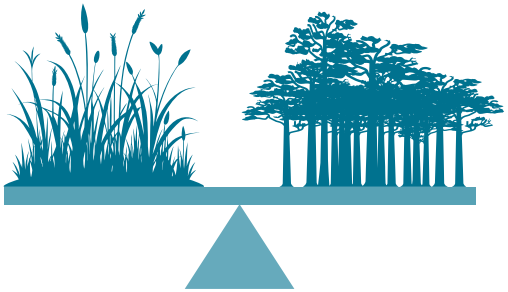
Grassland and savannah ecosystems have been amongst the most heavily converted because of their suitability for food production and settlement. They are often treated as marginal lands, wastelands, open space, and targeted for urbanisation, infrastructure, mining, and energy production. Temperate grasslands have undergone the most severe fragmentation of all biomes and flooded grassland and tropical grasslands have experienced dramatic land use change.[156] Less obviously, many grasslands have also been degraded, which can be equally damaging to their ecosystem services.

Conversion to agriculture and urbanisation

Conversion for food, tree plantations, textiles, fuel crops and livestock (by use of fodder crops and replanting grassland with non-native grass species) has resulted in the biome experiencing a higher rate of conversion and fragmentation than any other.[157,158,159] A rise in indoor or feedlot systems for livestock paradoxically means more grass is ploughed to produce animal feeds.[160] Native grasslands are converted to produce soy,[161] oil palm,[162] cotton,[163] wood pulp,[164] livestock feed such as corn/maize[165] and biofuels.[166] Further conversion could be triggered by new transportation and energy infrastructure, combined with a growing human population.[167]

Conversion is happening particularly fast in the tropics and the Americas. In South America, up to 78% of the Pampas and half of the Cerrado[168] has been lost in recent times to agriculture and intensive livestock,[169] whilst conversion is increasing in the Chaco in Argentina[170] and in montane grasslands in Brazil.[171] Moving north, the Valles Centrales of Chihuahua, a priority grassland area along the borders of the USA and Mexico, lost almost 70,000 hectares to croplands between 2006 and 2011.[172]

Conversion of intact grasslands to cropland is the largest threat to the Great Plains stretching across the United States, Canada and Mexico.[173,174] In 2021, plough-up destroyed 650,000 hectares of grasslands across the US and Canadian portions and almost 13 million hectares have been lost since 2012.[175] Agriculture is not the only driver, with urbanisation becoming increasingly important.



In California, residential and commercial development accounts for almost half of the 195,000 hectares of grassland conversion between 1984 and 2008.[176]

In sub-Saharan Africa, much savannah conversion is driven by development aid; the World Bank has proposed large-scale expansion of commercial agriculture into savannahs to provide economic development and alleviate poverty for growing African populations.[177]

Well-meaning forest conservation efforts have at times caused the leakage of agricultural expansion towards grasslands and savannahs.[178] For example, in the Congo basin an additional 4 million hectares of oil palm will be needed to meet demands by 2035, and due to forest protection efforts, new plantations are likely to be focused on savannah.[179,180,181] Similarly, in Brazil, the voluntary Amazon Soy Moratorium is increasing pressure on Cerrado savannah.[182,183] Lack of coordination between forest and grassland conservation efforts exacerbates these problems.

Indiscriminate afforestation

Some climate change mitigation strategies drive conversion directly, with resulting biodiversity and carbon losses.[184] Degraded grasslands,[185] savannahs[186,187] and natural grasslands mistaken for degraded forests[188] are increasingly planted with trees.[189,190] Afforestation destroys underground carbon stocks and grassland community composition which may take centuries to recover.[191,192] Drivers include a confusion between *reforestation* (restoring lost forests) and *afforestation* (planting trees where there has been no recent forest cover), overestimation of carbon sequestration potential, insufficient recognition of grassland ecosystem services and the "neocolonial" tendencies of many afforestation programmes, which have taken little heed of local human needs.[193]

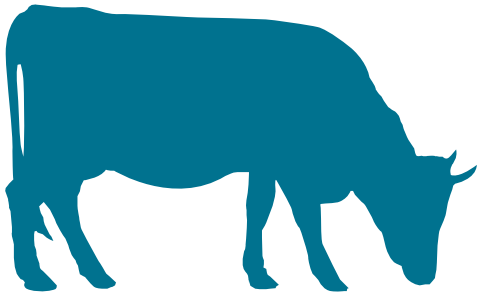
Such efforts seldom produce healthy forests. In China, many afforestation projects have taken place to reduce erosion and desertification. Of the trees planted since 1949 in historically non-forested areas, it is reported that only 15% have survived. One project planted over 105 million hectares of grasslands with trees between 1978 and 2005, but much of this is now apparently bare soil.[194]

Situations observed in several countries where efforts to meet restoration goals, including UNFCCC goals,[195] and the Bonn Challenge forest restoration target to restore 350 million hectares of forests,[196] are mistakenly used by governments to focus on quantity of trees rather than quality of forests,[197] or fail to take factor in the ecosystems being replaced and therefore do not adhere to FLR principles to guide these efforts, must be avoided. While initiatives like the Bonn Challenge discourage replacing natural grasslands, savannahs or other open ecosystems with forests, these guidelines have not always been followed and some global efforts to identify suitable reforestation areas have been criticised for including important grassland areas.[198,199] Increasing native tree cover is essential for carbon sequestration and conservation but must be guided by the principle of "right tree, right place" and not achieved at the expense of carbon and species-rich habitats like grasslands and savannahs.

Degradation: overgrazing, invasive species, loss of wild species and other pressures

Grassland degradation is recognised as a major problem. Accurate figures are hard to find, due partly to different definitions of "degradation".[200] Early estimates that almost three-quarters of rangelands were degrading[201] are now thought to be too large and much work has been done to increase accuracy, including bringing pastoralists' TEK into assessments.[202] Recent studies found a quarter of the world's grasslands undergoing a decrease in net primary productivity,[203] while the UNCCD's first *Global Land Outlook* estimated that around 20% of the Earth's vegetated surface was experiencing persistent declining trends in productivity, [204] and FAO classifies 34% of grasslands as degraded, some 246 million ha.[205]

Overgrazing: The term "overgrazing" is vaguely defined but is generally understood to mean grazing for a long enough period of time, or without sufficient recovery periods, to cause damage to vegetation cover.[206] In particular, disruption of natural grazing regimes, inappropriate grazing intensity, frequency and rotation periods are major problems, made worse by replacement of native grazers. Ancillary issues include retaliatory killings of predators.[207] Even low grazing pressure by animals not adapted to local ecology can cause degradation. A century of sheep grazing in semi-arid Patagonian steppe has reduced plant diversity and cover, carbon and nitrogen soil pools and microbial density.[208] Desertification now impacts over 90% of the region.[209] Many countries are undergoing increases in herd size, including among pastoralists.[210] Most African rangelands are, for instance, now estimated to be at or above grazing capacity.[211]



Changes in livestock husbandry, including a rapid increase in size and structure of livestock herds[212] and conversion of natural grassland to intensive grass monocultures, means that millennia-long sustainable production methods are now often a source of degradation and loss.[213] Degradation is, for example, a major issue in parts of China and the subject of much national action.[214,215,216]

The challenge of overgrazing is complex and can increase or decrease depending on:

- Politics, e.g., forced settlement of nomadic people[217] is an important factor in parts of Inner Mongolia, China[218] and East Africa,[219] while national border issues are problematic for pastoralists moving between countries in parts of West Africa.[220]
- Perverse incentives to have more livestock, e.g., tax breaks,[221] subsidised feed, or linking agricultural support to herd numbers rather than ecological carrying capacity, as in many European countries,[222] where 80% of the Common Agricultural Policy's subsidies support animal products.[223]
- Lack of incentives and investment for implementing sustainable rangeland management.[224]
- A squeeze on land due to expansion of cash crops,[225,226] e.g., rapid expansion of cash crops in Africa has created pressure on savannahs,[227] and grazing bans for either conservation or restoration can also result in additional pressures on grassland areas still available.[228,229]
- Demographic changes, population growth or decline, out-migration, in-migration, people moving in times of crisis,[230] such as COVID-19 restrictions in the Horn of Africa.[231]
- Emergence of a market economy amongst transhumant societies,[232] which can lead to a shift from pastoralism to ranching, as in Central Africa,[233] and using livestock as collateral against loans.
- Changing lifestyle expectations, such as children going to school and needing extra cash for uniforms, etc., can encourage bigger herds and more pressure on the land.[234]
- Tenure issues including concentration of land ownership, with e.g., artificially high grazer populations maintained for hunting[235] and absentee ownership by people distant from the impacts on the land.
- Ecological changes associated with climate change (increased droughts and weather extremes, new pests, introduced species and loss of predators).[236]
- Collapse of production systems along with forced displacement, evictions and the absence of realistic livelihood alternatives, which force people to raise livestock on marginal lands.
- Concentration of livestock around critical infrastructures that are becoming scarce (waterpoints, drove roads, reduced communal lands) generating pressure on surrounding lands.
- Cultural factors, including livestock numbers as an important symbol of status,[237] perhaps particularly in places where nomadic communities suffer discrimination.[238,239]

Most factors are largely out of the control of livestock keepers, although they are often blamed. Herders draw on centuries of knowledge of livestock management and have the strongest motive to maintain sustainability.[240] Some of the efforts to avoid degradation in one place can increase problems elsewhere, including fencing, land occupation and privatisation, grazing bans, border issues, occupation of drove roads and other restrictions on pastoral mobility.

The problem is growing. In Inner Mongolia, sheep numbers increased from 57 million in 1978 to almost 113 million in 2012, with many herders aware that grasslands cannot support these numbers.[241] In East and Central Africa, land privatisation has led nomadic pastoralists to claim and overgraze land parcels with flock sizes too large for the site.[242,243] In Tanzania, factors leading to overgrazing are the centrality of cattle keeping to cultural identity, lack of alternative livelihoods, and weak social cohesion and governance.[244] In the UK, lack of legislation and enforcement allows farmers to degrade national parks by overgrazing,[245] with pushback against incentives to reduce sheep numbers.[246] Cropland is also impacted; 33% of arable land is used for livestock feed,[247] disproportionately impacting grasslands.[248]

Under-grazing and abandonment: Conversely, in other parts of the world, *under-grazing* is significant. In places where livestock

have largely replaced native herbivores to form a partial replacement of the natural grazing regime, agricultural abandonment due to marginalisation and isolation from urban markets often leads to shrub and forest encroachment and consequent loss of grassland biodiversity.[249] This is currently affecting large areas of Europe, with impacts on biodiversity and many ecosystem services,[250] and parts of the United States where Western red cedar (*Thuja plicata*) is encroaching due to lack of fire and grazing.[251]

Pollution: Pollution comes in a variety of forms. Grasslands are degraded by agrochemicals which promote forest encroachment,[252] over-use of fertilisers[253] and fungicides which alter nutrient cycling and microbial communities and can reduce plant diversity,[254] and by dry deposition from atmospheric pollution.[255,256] Bee diversity declines with increasing nitrogen concentrations in grassland.[257] In fragmented landscapes, agrochemicals can drift into pasture from surrounding cropland,[258] for instance impacting grassland birds.[259,260] Soil insects in livestock areas are exposed to veterinary medication residues, which affect their survival, reproduction and functioning,[261,262] with impacts exacerbated by climate change.[263] Ivermectin is a widely-used antiparasitic drug that reduces the diversity, abundance and biomass of dung insects, even at low concentrations,[264,265] thus reducing the spreading of dung, which is important for grassland ecology.[266,267,268,269] Frequent use of anthelmintics, including ivermectin, is widely recommended to optimise livestock production, leading to soil biota depletion and nematode anthelmintic resistance.[270]

Invasive species: The introduction of non-native grasses and forbs[271] and the spread of invasive plant and animal species[272] affect huge areas, impacting native species, particularly plants,[273] and also reducing economic values.[274] Invasive tree or shrub species can swamp grassland,[275] while non-native grasses alter the physical structure of the area and the resources available for native species,[276] or modify soil structure to facilitate other invasive species[277] and hamper restoration.[278] Some invasive species are fire-adapted plants that increase fire risk in grasslands not adapted to fire, with impacts including additional release of carbon.[279] Dryland grass invasions in the western United States are estimated to deplete soil carbon in affected areas by 42-49%.[280] In some circumstances, native species can also become invasive due to particular management approaches, like bracken (*Pteridium aquilinum*) in Europe.[281]

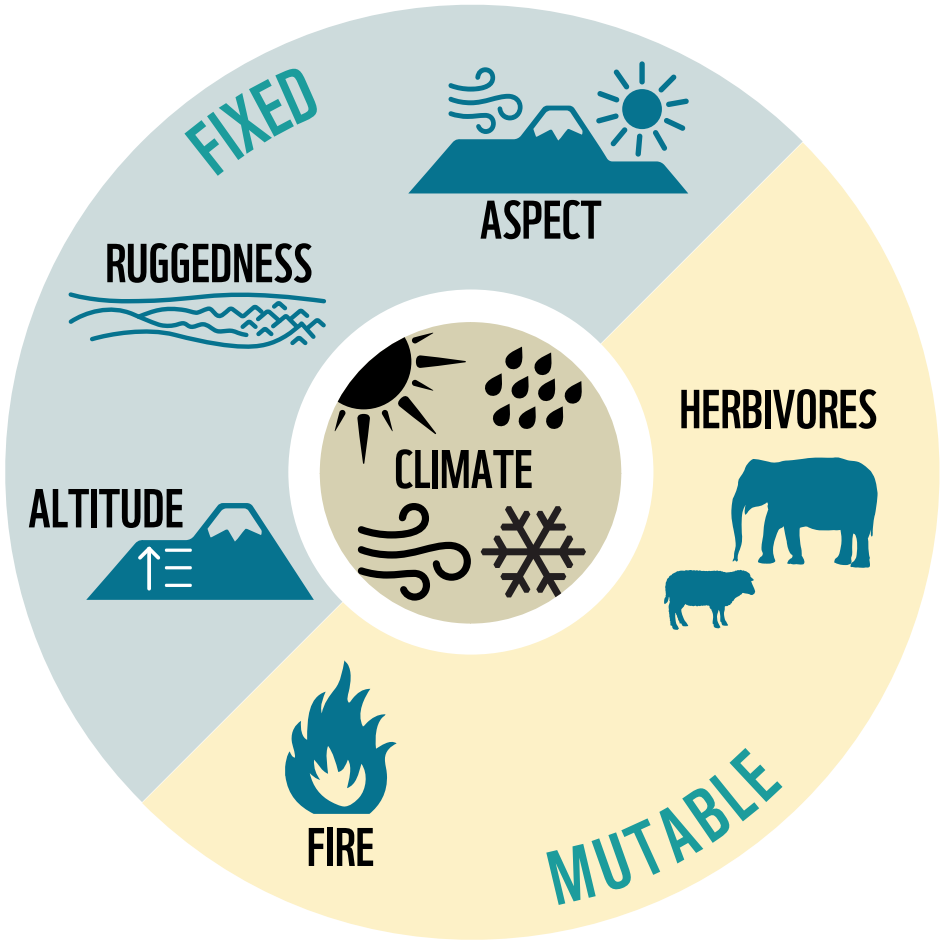


Figure 1: The forces that maintain and create grasslands

Fragmentation: Management also impacts ecological connectivity. Fences are one of the most widespread artificial features on Earth, and may outstretch roads by an order of magnitude,[282] mostly for livestock and infrastructure.[283] In the western United States, without including urban and suburban property fences, over 1 million kilometres of fences dissect the countryside.[284] Fences alter nutrient flows and plant composition, redistribute wildlife and reduce biodiversity.[285] The range restrictions created by fencing drastically reduce the abilities of livestock and wildlife to move nutrients like phosphorus or nitrogen across landscapes.[286,287,288,289] Livestock fences in some parts of the world have also directly led to the loss of large predators such as Australia's dingoes (*Canis lupus dingo*).[290]

Alteration of natural disturbance factors that maintain grasslands

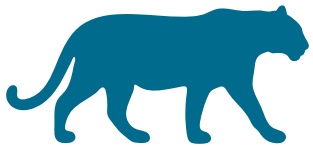
Ecologists once believed that ecosystems developed towards "climax communities"; terrestrially this implied old-growth forest systems ("wildwood"). Yet old-growth grasslands exist naturally in areas where the climate, topography, natural disturbance regimes and herbivores promote grasslands over forests.[291] The loss of these factors can shift grasslands into forests or deserts. In recent decades many herds of keystone herbivores,[292] and Indigenous burning practices that maintained grasslands,[293] have been significantly reduced or lost. Climate change is also altering the precipitation levels and temperatures that have kept grasslands stable for millennia.[294]

Loss of keystone native herbivores

Herbivores are often critical to maintaining grasslands.[295] Unlike trees which grow from the top, grasses grow from the bottom of the stem and regular grazing stimulates growth. The native grasses of the North American plains co-evolved with bison (*Bison bison*), which prefer taller grasses, with their browsing keeping grass young and green.[296] In East Africa, wildebeest (*Connochaetes taurinus*) fill much the same niche, and in converting grass into dung and soil organic carbon (SOC), they play a crucial role in keeping fuel loads low, thus reducing extreme fires.[297] Due to exposure to rinderpest, wildebeest populations almost disappeared, but when the disease was eradicated in the 1960s populations bounced back. In consequence, fewer wildfires occurred – switching the Serengeti ecosystem from a carbon source to a carbon sink absorbing several million tonnes of CO_2 annually.[298]

Grassland ecosystems are often phosphorus and nitrogen limited and migratory grazing herds like bison and wildebeest play a huge role in cycling these nutrients.[299] Their excrement and carcasses[300] fertilise the grasses and their long migratory patterns bring nutrient subsidies to areas of low concentrations,[301] keeping the grasslands healthy and less vulnerable to climate instability. In North America, this effect is now referred to as the *Green Wave*,[302] a phenomenon many Native American groups have been aware of for thousands of years.

However, large herbivores have undergone dramatic population declines and range contractions and some 60% face extinction.[303] As they decline, grassland plant diversity declines,[304,305] nitrogen and carbon stocks are destabilised,[306] fire prevalence and intensity



In many places, predators are viewed as threats to livestock and are persecuted: either through active removal or retaliatory killing after conflict

increase along with invasive plant species.[307] Wild herbivores are often viewed as harmful to livestock due to competition for fodder, water and space. In Argentina, guanacos (*Lama guanicoe*) and Darwin's rhea (*Rhea pennata*) can be forced away from lands grazed by sheep.[308,309] In Mongolia where a recent sheep and goat plague outbreak has devastated saiga (*Saiga tatarica*) numbers, sheep herders have a growing antipathy to saiga, fearing they will infect livestock.[310] Many grassland soil engineers, such as plateau pikas (*Ochotona curzoniae*), zokors (*Eospalax spp.*)[311] and prairie dogs (*Cynomys spp.*),[312] have been actively exterminated due to a belief that they compete for forage and degrade ecosystems through soil disturbance.[313] The loss of these species causes destabilisation of grassland nitrogen and soil carbon stocks,[314] an increase in invasive plant species and fire frequency,[315] and a reduction in biodiversity.[316] Across much of the world, full ecological recovery of grasslands will require the restoration of large, wild herds moving over extensive and diverse landscapes.[317]

Replacement of wild herbivores by livestock has several knock-on effects. Herbivore carcasses fertilise habitats, sometimes *en masse*. In East Africa, migratory herds are subject to mass drownings when making dangerous river crossings. Their bones release phosphorus into the water and soils over many months.[318,319] In the North American Great Plains, it is estimated that bison, once numbering in their millions, would have lost 200,000 in similar annual mass drownings, donating 90,000 tonnes of phosphorus each year.[320] Today, in many countries farmers are legally obliged to remove dead livestock. For example, the UK government mandates that carcasses must not be burned, buried or fed to any necrophagous birds, but transported as soon as possible in a leak-proof container to a hunt kennel, maggot farm, incinerator, etc.[321] These policies are primarily to prevent the risk of spreading disease through residues in the soil, groundwater or air. However, they also ensure that livestock carcasses transfer minimal nutrients to the ecosystem, unlike wild herbivores.

Conflict, persecution of predators and prevention of their return

In many places, predators are viewed as threats to livestock and are persecuted: either through active removal or retaliatory killing after conflict. Predators do indeed take livestock, creating challenges for pastoralists and ranchers. But combined with habitat loss and degradation, and the utilisation and depletion of the prey base, the control of predators has caused significant declines in populations and geographic ranges,[322] with knock-on impacts on ecology and ecosystem services.[323]

In East Africa, Maasai pastoralists often retaliate against predator species that take livestock.[324] In northern Iran, the endangered Persian leopard (*Panthera pardus saxicolor*) was pushed to the verge of extinction from killing as a response to cattle depredation.[325] On the borders of Switzerland, a French sheep breeders' association historically demanded the eradication of all wolves and lynx[326] despite livestock representing only 0.6% of lynx kills.[327] In temperate South American grasslands, pumas (*Puma concolor*) that take sheep are killed.[328] Where predators have been lost, livestock lobbies continue to block the restoration of predatory species.[329]

Associated biodiversity loss

Loss and degradation of grasslands can lead to cascading ecosystem effects on species' interactions, food webs and resilience. Loss of one species has indirect effects on others, threatening the stability and functioning of ecosystems and ecosystem services. Loss of native grassland impacts flora,[330] insects,[331] reptiles,[332] birds[333] and mammals. Grassland loss and fragmentation, and encroachment into a previously open ecosystem, lead to declines in biodiversity. For example, as the North American prairies were converted to farmlands from the 18th century, populations of black-footed ferrets (*Mustela nigripes*) and their prey, the prairie dog (*Cynomys ludovicianus*), plummeted. Prairie dog burrows make it difficult to cultivate crops and are blamed for cattle injuries. They are easy to locate in open grasslands and have been heavily persecuted.[334] This also led to the near-extinction of black-footed ferrets as prairie dogs are a principal food source.[335] Effects are often seen only gradually, as decreasing habitat size and connectivity create conditions in which species slowly decline and are lost ("extinction debt"),[336] with intensification processes also playing a key role in biodiversity decline.[337]

Alteration of the fire regime through changes to Indigenous burning and other practices

Many grasslands ecosystems have adapted over millennia to intentional landscape burning by Indigenous people to clear and maintain open vegetation for resource use,[338] sometimes matched with deliberate tree cultivation to create savannah landscapes.[339] There is evidence of burning across six continents, but it is particularly prevalent in Australia, Africa and the Americas.

Indigenous burning practices have a number of objectives, but one effect is reduced encroachment by woody plants into grasslands. Unlike fires caused by lightning strikes, Indigenous burnings typically occur in cooler, moister seasons.[340] This has historically ensured that fuel load remained at low levels in dry seasons. Intentional burnings were controlled and most of the carbon stored in the ecosystem was safely below ground.[341] Indigenous peoples have also used fires to attract herbivores for hunting.[342] Herbivores are attracted to, and concentrate their foraging on, recently burned areas of new grass shoots, this cycle leaves other areas to accumulate a greater fuel load which enables future fires, keeping woody plants rare.[343] This phenomenon has been termed pyric herbivory.[344]

With the arrival of colonial Europeans, Indigenous people were generally driven from their lands. Traditional burning practices in Australia and North America were suppressed.[345,346] In Oregon and Washington, it is estimated that over 180,000 ha of land was burned annually before colonial settlement,[347] but legislation criminalised traditional burns in both the USA and Australia.[348,349] Cessation of traditional practices has led to increased woody encroachment, a loss of grasslands and a heightened risk of extremely destructive fires, particularly in the face of climate change,[350,351,352] although steps are now being taken to reintroduce traditional fire management in places.[353] While fire suppression is changing ecology in fire-dominant ecosystems,[354] in other places an increase in accidental fires and arson is leading to greater fire impacts, often exacerbated by climate change.

Other traditional practices are also being abandoned, like night kraals, enclosures or redileo, which concentrate livestock for short periods, managing vegetation and boosting fertilisation, thus also diversifying grasslands.[355]

Climate Change

Climate change can increase variation in precipitation and temperature.[356] This "global weirding" is expected to decrease grassland productivity[357] and cause longer, more severe droughts resulting in desertification,[358,359] along with extreme flooding and wildfires. It can exacerbate other drivers of grassland degradation, e.g., in Central Asia where overgrazing is combining with more intense and frequent droughts.[360] Grassland loss through overgrazing, fire and invasive species disturbs soil and leads to erosion or desertification, releasing carbon and further accelerating climate change.[361] Currently, at a global level, grassland emissions are around neutral, with CO_2 absorbed by natural grasslands offset by extra emissions from intensively managed grasslands and those established on forests and other ecosystems.[362] However, if we continue to convert grasslands at the current rate, by 2050 it is estimated this will lead to 4.25 gigatons of emissions globally from the biome.[363] Elevated CO_2 promotes woody species, increasing encroachment. Some non-native, invasive and fire-adapted grasses increase fire risk in ecosystems not adapted to fire, releasing more carbon.[364] Indirectly, there is also a risk that climate change will lead to an expansion of agriculture and the conversion of grasslands in areas where longer growing seasons make crop production more profitable.[365]

Climate change and grassland loss thus exhibit a classic positive feedback loop. Whilst increased atmospheric CO_2 and climate change are a major driver in the loss of grasslands,[366] grassland losses and degradation exacerbate climate change through a number of pathways.

But grasslands with a healthy, diverse community of plants and wildlife can help to mitigate many of these effects.[367,368] Healthy grasslands reduce soil erosion, dust storms and desertification,[369] and have a high resilience in the face of environmental change.[370,371] They exert a strong influence on global climate through atmospheric cooling due to their high surface "albedo" (ability to reflect sunlight). Grasslands typically have a high albedo due to their light-coloured surfaces, so they reflect a large portion of the sunlight that hits them back into the atmosphere, thus keeping the surface cooler. This is particularly important where temperatures rise to extreme levels.[372] In some regions, grasslands help to preserve permafrost by allowing cold winter temperatures to penetrate deeper into soils, providing a net cooling effect and delaying permafrost melt. Preserving permafrost is crucial for preventing the release of large amounts of methane, another potent greenhouse gas.[373]

It has been estimated that on severely degraded land as little as 5% of total rainfall is used productively

The implication of grassland loss for ecosystem services

The loss and degradation of grasslands compromises ecosystem services, impacting human communities. Soil, the Earth's fragile skin, is made up of countless species creating an ecosystem of priceless value to people. Healthy grasslands play a crucial role in stabilising soil through the plant root systems. When grasslands are converted or degraded, the protective cover of vegetation is reduced, leading to erosion.[374] Grassland soil quality is damaged by compaction from large, intensively managed livestock herds or agricultural vehicles,[375] by nutrient degradation through the loss of wildlife nutrient subsidies,[376] and loss of structure and changes in salinity;[377] all resulting in the loss of topsoil and decreased productivity.[378]

Further ploughing of grassland will increase losses of ecosystem services. Increasing erosion could present an acute challenge to food security in vulnerable regions in Africa[379] and other tropical areas.[380] The impacts of soil erosion are well known. During the 1930s Dust Bowl in the USA, over 30 million hectares of soils were severely damaged due to the loss of long-rooted grasses from ploughing the prairies combined with a period of drought,[381] resulting in much human suffering,[382] movingly portrayed by the Nobel prizewinning writer John Steinbeck in *The Grapes of Wrath*.[383]

Healthy grasslands play a crucial role in regulating the hydrological cycle by capturing, storing and releasing water. They act as natural sponges, absorbing rainfall and reducing surface runoff, which helps to recharge groundwater supplies, mitigate flooding,[384] and maintain streamflow in dry periods.[385] The movement of water into grassland soil is decreased on average by over half when grasslands are livestock-grazed or cropped.[386] When grasslands are degraded, their ability to regulate water is diminished, leading to increased fluctuations in water availability. It has been estimated that on severely degraded land as little as 5% of total rainfall is used productively.[387]

Community, cultural and economic impacts of changes to grasslands

Biodiversity supports ecosystem services which in turn support human livelihoods. As the health of the grasslands suffers, so too does the wellbeing of its human inhabitants, who face mounting threats to livelihoods and food security.[388,389] This includes a decline in livestock productivity, as animals may have limited access to nutritious forage, resulting in lower meat and milk production.[390]

All the pressures noted above impact first on people living most closely to the land. In East Africa, soil erosion undermines economic development and cultural stability.[391] For pastoralists, livestock rearing is central to cultural identity and the deterioration of grasslands has significant impacts on social cohesion, exacerbated by a lack of alternative livelihood opportunities.[392] In Latin America, increasing pulp plantations on native grassland combined with land conversion, mostly to soybean monocropping,[393] have been accused of undermining the traditional gaucho lifestyle.[394]

These pressures are made worse by the discrimination faced by smaller livestock herders and other users of grassland. Land tenure insecurity has worsened clashes between herders and settled farmers.[395] Poorly planned conservation projects can block access to nomadic herders.[396] Tourism can impact cultural services,[397] interfering with traditional practices or reducing them to a spectacle.

Globally, conversion and degradation of grasslands, combined with political pressure on pastoral communities and shifts away from traditional lifestyles are leading to a loss of pastoralism and cultural values associated with grasslands.[398,399] All these factors disrupt the structure and functioning of grasslands.[400] Ultimately, management of grassland depends on the people living there, and improving their security and livelihoods must therefore be the first step in addressing loss and degradation. Yet natural grassland is still often undervalued in conservation policies.[401]

PRIORITY GRASSLAND AND SAVANNAH HABITATS

Key points:

- Important and globally unique grasslands are found across cultural, geographical, elevational and moisture gradients and across the biogeographic realms.
- They can be classified in various ways, e.g., in terms of their ecological and socio-cultural importance, ecosystem services and for their value to food security.
- A methodology for identifying priority areas is suggested.

Policy entry point:

- To facilitate more effective conservation strategies and investment, policies need effective frameworks for identification of priority grasslands from the perspectives of biodiversity, ecosystem services and human cultures.

While there is a global need to conserve and reverse degradation of grasslands and savannahs, some grassland ecosystems will clearly be of higher priority, because they support rare or important assemblages of species, perform key ecosystem services, are underrepresented in protected and conserved areas, are important for food security or support threatened human cultures.

Identifying priority sites is important, but complicated, as priorities depend on who is doing the prioritisation, with different actors having valid reasons for highlighting different criteria. We therefore do not attempt a single priority list but instead consider criteria for distinguishing grasslands and savannahs from ecological, socio-cultural and ecosystem service perspectives. A more detailed matrix should help users to rate some important characteristics of healthy, natural or semi-natural grasslands.

What is a grassland?

One problem in identifying grassland priority sites is that broad classification systems don't always help. There is no agreed definition of grassland: one from 2000 suggests: "*terrestrial ecosystems dominated by herbaceous and shrub vegetation, and maintained by fire, grazing, drought and/or freezing temperatures*".[402] Savannahs are considered to be grassland with a scattering of trees. But the FAO definition of a forest (trees over 5 metres tall and 10% canopy cover)[403] will cover the same areas as many savannahs. The transition between grassland and shrubland is even more vague.

There have been various attempts to delineate different grassland types. WWF's 867 terrestrial ecoregions include hundreds of tropical and subtropical grasslands, savannahs and shrublands, flooded grasslands and savannahs and montane grasslands and shrublands.[404] The IUCN Global Ecosystem Typology delineates five functional groups in the savannahs and grasslands typology: *trophic savannas*, *pyric tussock savannas*, *hummock savannas*, *temperate woodlands* and *temperate and sub-humid grasslands*.[405]

Smaller grassland areas within other ecosystems (e.g., forests) tend to be missed in global ecosystem maps. Yet some of the grasslands with the highest biodiversity and greatest threat are subsets of forest or wetland ecosystems, where grass is present only on an occasional and cyclical basis or in small patches, e.g., northern European ecoregions are defined as "forest" but contain important grasslands. A focus only on permanent or semi-permanent grasslands misses some of the world's most important and at-risk grassland patches. Many grasslands exist in a constant, natural flux with woodlands, for example comparison of maps of trophic savannas[406] and tropical and subtropical dry forests and thickets[407] in Africa on the IUCN typology shows considerable overlap. It is therefore important to align map section with purpose. An understanding of the temporal element is also important. By including changes over time, grasslands might be represented as follows:

- **Permanent or long-term grasslands**: where herbaceous plants thrive and perhaps outcompete trees. Moreover, trees cannot normally grow due to altitude, aridity, cold, water table, etc., e.g., Andean and Central Asian mountainous regions and parts of the Middle East.
- **Frequent cyclical grasslands**: where regular fire, grazing, browsing, flooding and other ecosystem processes maintain savannah habitat dynamics and forest cover that ebbs and flows over time, e.g., Cerrado or East African savannah.
- **Occasional cyclical grasslands**: where ground cover is predominantly forest, but irregular fires or other disruptors create grassland for relatively short periods of time, e.g., in Western Europe.

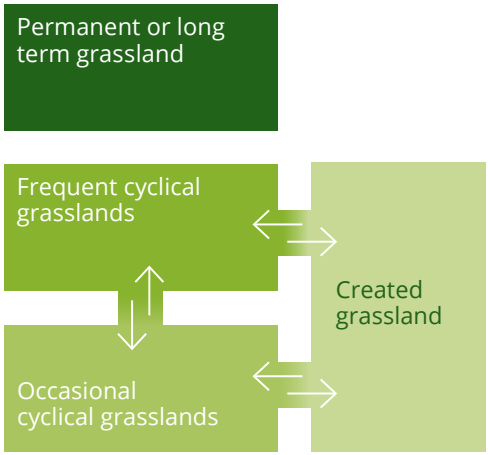


Figure 2: Broad categories of grassland and savannah based on ecological function

There is also a fourth "category":

- **Created or derived grasslands**: areas cleared of trees by humans or where grassland species have been transformed; some will be wholly artificial, others near-natural in composition but "permanent" in a way that would not occur without management, e.g., Swiss cultural grasslands.

These are approximations and the boundaries are sometimes fuzzy, particularly between "frequent" and "occasional". They could be depicted as follows: shown in figure 2.

Most maps of grasslands and savannahs show *permanent* and *frequently cyclical* grasslands, missing those that are naturally a minority part of the landscape or have retreated due to human-induced changes (e.g., loss of native herbivores) and – except for agricultural maps – ignoring created grasslands. In the case of "frequently cyclical grasslands", the overlap with forests is complicated. Some discrepancies can be addressed by choosing the optimal map for the information required.

Identifying the most important grasslands

Over the last 30 years, huge efforts have gone into comparing one place with another and finding priorities for action: of conservation sites, Indigenous territories, landscapes of cultural importance and, increasingly, ecosystem services. Perhaps we overemphasise the ideal, life is messier than neat lines on maps. But with limited resources and competing demands, some idea of where best to focus attention is important. All grassland and savannah habitats are likely to have, to a greater or lesser degree, value for all of the following:

- Biodiversity
- Human cultures
- Food production
- Other ecosystem services

As we have shown, food production dominates decisions about grassland use. Whilst acknowledging the critical importance of food security, here we focus mainly on the other three values, all of which have tended to receive relatively less attention when it comes to making decisions about land management. Prioritising one site over another means looking at relative importance, both *for what* and *to whom*. Prioritisation also relates to the degree of threat; a sustainably functioning and secure ecosystem supporting people, wildlife and ecosystem services can be left well alone.

Plenty of land use prioritisation tools exist: maps of Indigenous peoples' territories under varying tenure arrangements,[408] lists of important watersheds,[409] carbon stores,[410] key biodiversity areas,[411] etc.; and at landscape level tools such as systematic conservation planning[412] and high conservation areas.[413] Gap analysis can be applied to identify places where appropriate management, protection or tenure are absent.[414] And human cultures, biodiversity and ecosystem services are all influenced by similar factors: (i) area remaining; (ii) status, such as ecosystem condition or human health and livelihoods; (iii) a measure of security such as tenure arrangements, extent of protected areas or other effective area-based conservation measures (OECMs), and management of ecosystem services; and lastly (iv) threats and pressures of various kinds.

A prioritisation process for global or local conservation initiatives needs to consider three different functions or values (human culture, biodiversity and ecosystem services) with respect to both status and threats. Priorities are informed by what is happening in the rest of the landscape, where some kind of gap analysis[415] is important. Although different people or teams will have different priorities, all need to be aware of and accommodate other perspectives and needs.

Identifying important grasslands and savannahs from a biodiversity conservation perspective

Definitions of "*old growth grassland*",[416] "*high value grassland*",[417] "*ancient grassland*"[418] and "*primary grassland*" are available, alongside concepts of "*intactness*"[419] or "*authenticity*",[420] but there is no agreed typology. Neither is it easy to distinguish intactness or biodiversity richness by remote sensing, necessitating expensive ground surveys. In the following typology, distinction is made by type of management, recognising that this is an approximation.

1. Long-established native grassland ecosystem without livestock, but with expected native animal species including herbivores and predators.
2. Long-established native grassland ecosystem without livestock, with expected native herbivores and other species but where major predators have been lost.
3. Long-established native grassland ecosystem with light livestock grazing and no pesticide or fertiliser use, no artificially sown or non-native grass species, often also with some native herbivores and possibly predators.
4. Grassland under restoration and resown recently with native grass species with or without native herbivores or predators.
5. Long-established native grassland ecosystem with intensive livestock grazing and/or pesticide or fertiliser use and/or artificially sown or non-native grass species, with few native herbivores or predators.
6. Grassland sown with non-native species on the site of other ecosystems or grassland resown with or heavily invaded by non-native grass species, with few if any native herbivores or predators.

Grasslands in (1) and (2) could be classified as old-growth or similar and those in (3) as well-managed rangelands. All have important conservation values. It is fair to say that there is a continuing debate about the extent to which domestic livestock can replace native herbivores in terms of ecosystem functioning, with the balance depending on what kinds of livestock and what kind of ecosystem. Grassland in (4) could be a restored ecosystem although the type of restoration will determine its conservation value. Grasslands in (5) are likely to have high agricultural value but often limited

Degree of grassland naturalness	Likely conservation value
Long-established native grassland, no livestock, native herbivores and predators	Always has conservation value
Long-established native grassland, no livestock, native herbivores	Almost always has conservation value
Long-established native grassland, few well-managed livestock, organic, some native herbivores	Often has conservation value
Recently replanted with native grass species with or without native herbivores and predators	Conservation value depends on other issues, including wild species remaining, management intention, potential for restoration.
Long-established native grassland, many or badly managed livestock, and/or agrochemicals	
Grassland sown on site of other ecosystem or grassland resown with non-native grass species	Usually little conservation value, may be suitable for restoration*

* Note that replacing crops grown on marginal land with non-native grass species, while not being as desirable as full restoration of native grassland, can nonetheless have significant conservation value.

Figure 3: Broad categories of grasslands and savannahs based on naturalness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conservation value albeit suitable for restoration, e.g., by implementing better grazing practices, converting to an organic system or reintroducing native herbivores and predators. Non-native grassland monocultures as in (6) will generally have the lowest conservation values although these intensive pastures will produce the highest food values in terms of meat and dairy. So, from a biodiversity conservation perspective:

These are not exact. They do not factor frequency and type of fires (including those set by humans or exacerbated by climate change) or natural disturbance, which all influence ecosystem quality.

An extra complication is that the term "natural" is poorly defined. Many grassland ecosystems evolved with humans present, so the old idea of "natural" meaning without human influence does not work (it also assumes humans are not part of nature). Some changes have been profound:

- All or virtually all grasslands have been so altered by grazing pressure or fire management that any theoretical baseline is no longer recoverable. The first written records of grassland in Uruguay and Argentina come from 19th century travellers like Charles Darwin, several hundred years after settlement by Europeans and millennia after original human settlement.[421]
- Most grasslands have been "truncated" because natural disturbance patterns have been disrupted, due to e.g., extinction of megafauna,[422] fire management and habitat fragmentation.
- Most have also been altered by the arrival of non-native species of plants and animals.[423]
- Grasslands are highly dynamic ecosystems, with change inherent, and it is often difficult to distinguish change created by humans from natural evolutionary developments.

Natural is at best an approximate term,[424] but useful in distinguishing from grassland systems that are dramatically altered – e.g., because they have lost key ecosystem functions or consist of exotic species – and in monitoring no-conversion commitments. To provide more nuanced guidance for conservation value, Table 1 breaks down some of the important components of natural grasslands and savannahs and divides each into five different levels


© Equilibrium Research

Invasive lupins in New Zealand grassland

of naturalness, to provide a rough guide to the importance of a particular grassland ecosystem from a conservation perspective.

From a practical point of view, priority grasslands for biodiversity at a global scale are likely to fall into three groups:

- **Remaining large areas of intact or near intact natural grasslands** which maintain, or could regain, a natural ecological functioning, such as "nature's strongholds"[425] or grassland key biodiversity areas.[426]
- **Remnant, often high biodiversity grasslands that are under high pressure** that may be much smaller but require immediate conservation actions to retain species, including becoming part of a protected and conserved area network, such as Alliance for Zero Extinction (AZE) sites.[427]
- **Areas important for maintaining connectivity** such as ecological corridors or stepping stones for migrating birds.[428]

Table 1: Matrix of the various elements of naturalness

	Element	High grassland naturalness				Low grassland naturalness
 Constituents	Wild herbivores	Intact assemblage of native herbivores in abundance	Herbivore assemblage is intact but not abundant OR abundant but some key species are missing.	Herbivore assemblage is missing some species and abundance is fairly low but herbivory effects are still evident.	Many herbivore species are missing and abundance is very low, herbivory effects on grasslands are weak.	No native herbivores remain.
 Constituents	Wild predators	Intact assemblage of native predators in abundance	Predator assemblage is intact but not abundant OR abundant but some key species are missing.	Predator assemblage is missing some species and individuals are fairly rare but predatory effects on grasslands are still evident creating habitats complexity.	Most predator species are missing (may be evident from herbivore overpopulation, some overgrazing, reduced habitat complexity and some impacts on indicator species).	No native predators remain or only meso-predators (may be evident from herbivore overpopulation, overgrazing, low habitat complexity, collapse in indicator species).
 Constituents	Birds present	Intact assemblage of native birds and migratory birds in abundance	Bird assemblage is intact but not abundant OR abundant but some key species are missing. Migratory birds are still fairly reliable.	Bird assemblage is missing some species and abundance is fairly low indicating poor habitat. Migratory birds are becoming less reliable.	A few common bird species remain, maybe over-abundant or abundance of all species may have collapsed. A few migratory birds visit but are rarer.	No or very few native birds or migratory birds remain.
 Constituents	Indigenous flora species	>80% of grassland is native flora	Between 60-80% of grassland is native flora.	Between 40-60% of grassland is native flora.	Between 20-40% of grassland is native flora.	<20% of grassland is native flora.
 Ecosystem history	Age	Old growth grassland (300+ years old)	100-300 year old grassland on site that was historically a grassland.	30-100 year old grassland on site that was historically a grassland.	>30 year old grassland on site that was historically a grassland.	Frequent transformation / disturbance. OR grassland sown on site of another 7ecosystem.
 Ecosystem history	Originality	Original established grassland (no anthropogenic changing of states)	Limited supplementary sowing of wild species with efforts made to increase diversity of native species, ages, etc.	Some clear supplementary sowing of wild species.	Much of the grassland has been artificially restored showing some uniformity of age-ranges and species mixes.	Replanted grasslands (e.g., with uniform age-ranges, species mix).

Table 1: Elements of grassland naturalness (continued)

	Element	High grassland naturalness				Low grassland naturalness
	Extent / connectedness	Large area, unfragmented and connected	Extent is somewhat reduced, partially fragmented and/ or unconnected but most ecosystem function still remains.	Extent is reduced, partially fragmented and/or unconnected, some ecosystem functions are eroding.	Grassland area is small and/or fragmented and/ or unconnected. Ecosystem functionality has depleted.	Small area, highly fragmented, unconnected. Ecosystem functionality is highly depleted.
	Livestock use	No non-native livestock	Non-native livestock are present, extensive and sustainable, with coexistence measures.	Non-native livestock are present, extensive but with no grazing plans or coexistence measures.	Non-native livestock are present, grazed intensively with some consideration of biodiversity, weak coexistence measures may be in place or not adhered to.	Intensive livestock use (with evidence of overgrazing).
	Harvesting / extraction	Unharvested / no extraction	No large-scale grass harvesting, some minor product collection (e.g., grass for baskets, fungi, herbs, etc.) practised sustainably.	Grass is harvested after nesting birds have fledged. OR some non-grass product collection with some sustainability measures.	Grass is harvested seasonally or non-grass product collection is frequent with little thought to sustainability.	Harvesting year-round or with no consideration of faunal/ floral lifecycles.
	Soil health	No biocides or inorganic fertilisers, high biological activity, balanced soil nutrients including carbon, no soil compaction/erosion	No biocides and/or inorganic fertiliser use for several years. Good levels of biological activity, soil structure and nutrients. Some minor soil compaction or erosion.	No biocides and/or inorganic fertiliser use for 1 year. Medium levels of biological activity, soil structure and nutrients. Some soil compaction or erosion.	Some biocides and/or inorganic fertiliser in use. Poor biological activity, soil structure and nutrients. Clear evidence of soil compaction or erosion.	Biocides and/or inorganic fertilisers in high concentration, low biological activity and soil carbon, erosion and compaction at serious levels.
	Harmonised management & restoration	The management system values all authenticity/ natural qualities listed above	The management system values some of the authenticity qualities listed above.	The management system makes no attempt to address the above-listed authenticity qualities.	The management system is inadvertently degrading the authenticity qualities listed above.	The management system is actively degrading the authenticity qualities listed above.

Management

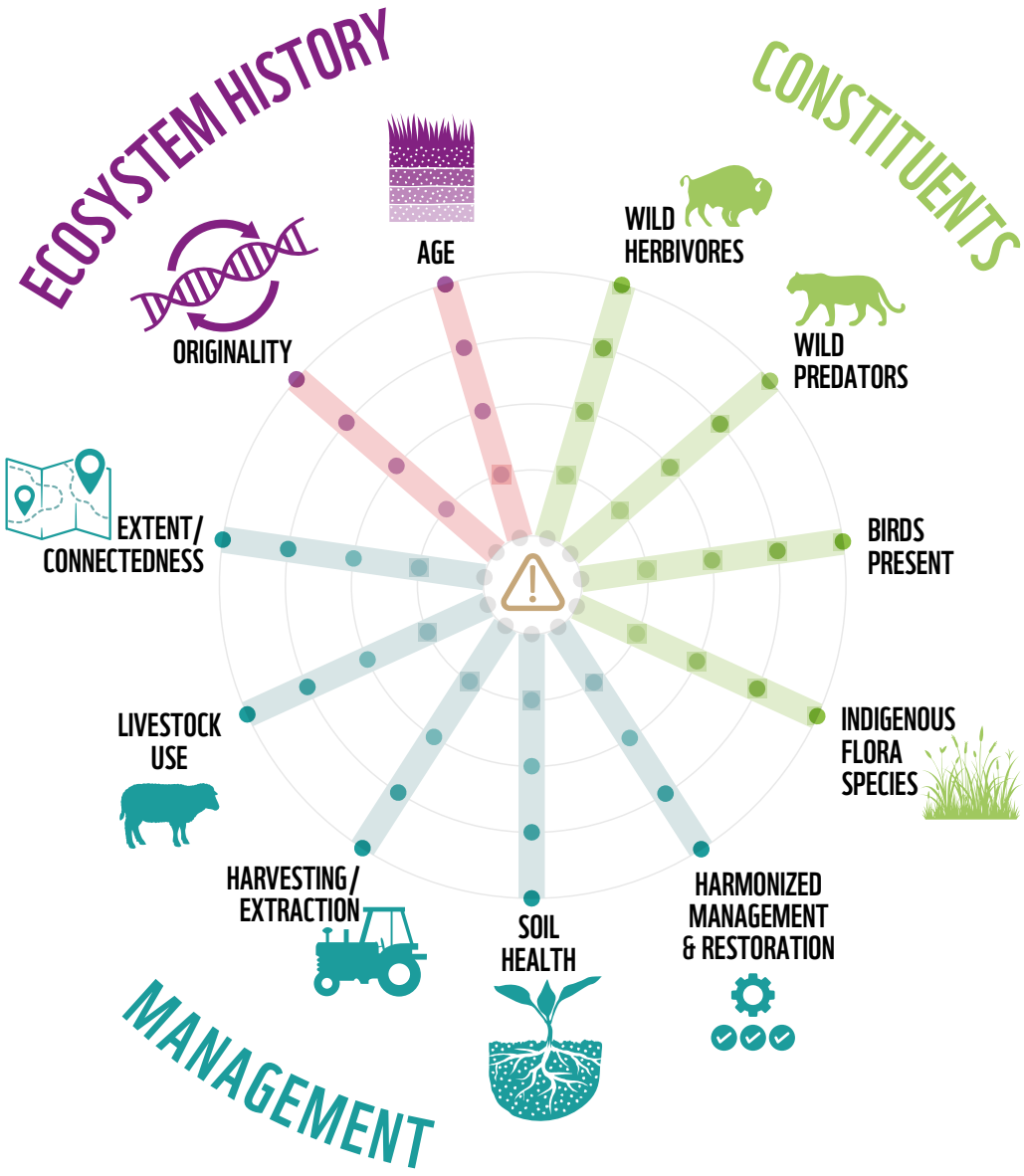


Figure 4: Blank spider chart on which, using the matrix above, the naturalness of grasslands could be mapped and cross-compared.

The matrix in Table 1 attempts to capture the key elements representing the rather slippery concept of naturalness in ecosystems; the deeper the colour indicating closer links to natural ecosystem functioning. It is indicative, many aspects of grassland ecosystem functioning are necessarily omitted. Disaggregation of this kind has its limitations but helps make the point that many grasslands will have some elements functioning reasonably naturally while others have been profoundly influenced by human management. Note too that this is descriptive rather than judgemental.

A grassland predominantly in the lighter green columns will be less natural but may have huge economic, social or cultural values; as always, this is determined by what users wish for.

The matrix can be used as a way of thinking about naturalness at ecosystem level and is not intended to be a precise diagnostic tool. It could, and in future perhaps should, be extended or duplicated to consider social, ecosystem service, and food values.

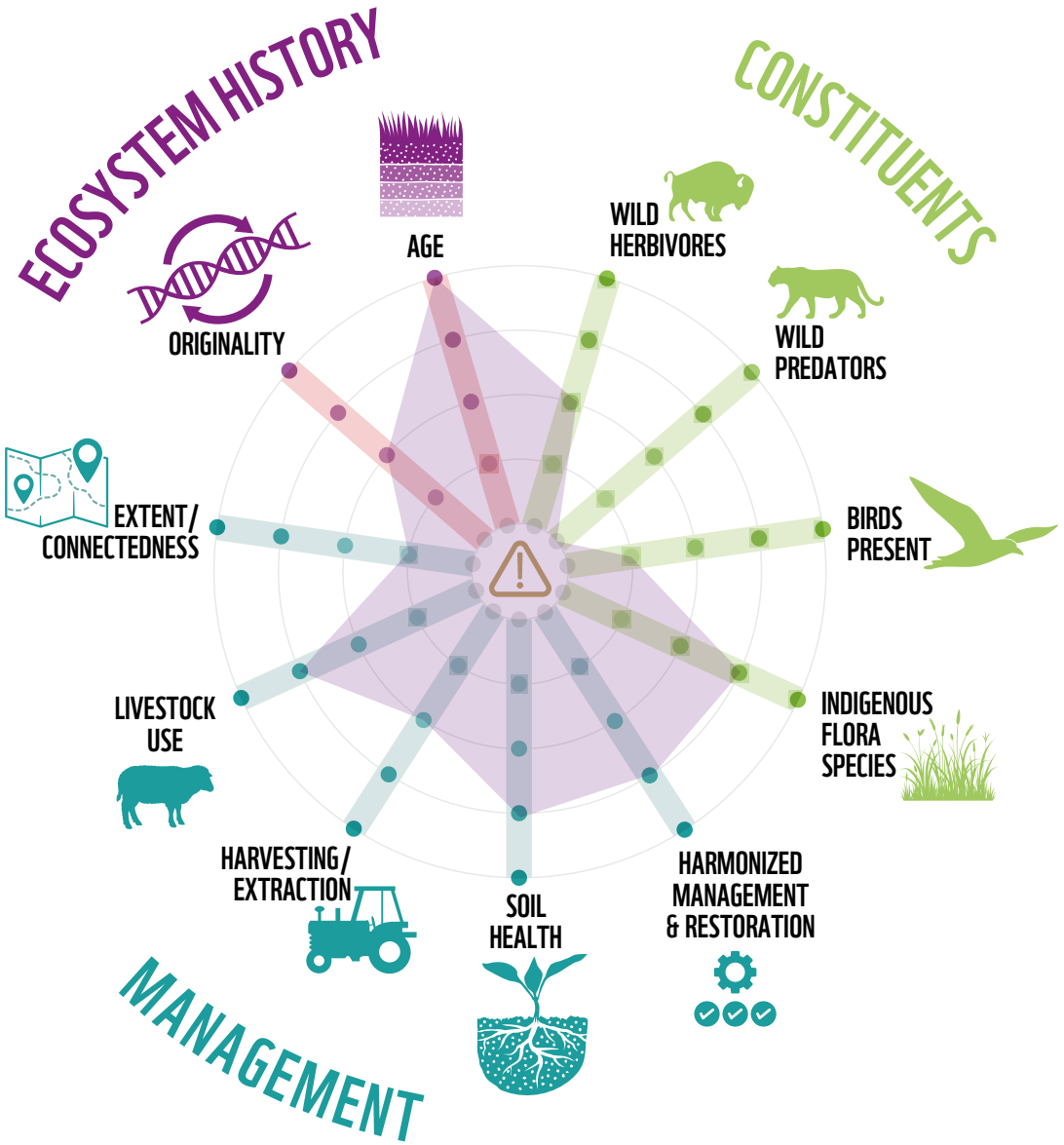


Figure 5: Naturalness spider chart for hypothetical grassland Earnshaw Wildmeadows

Hypothetical Grassland: Earnshaw Wildmeadows

Earnshaw Wildmeadows is a small, fragmented grassland landscape in North-East UK. Historical land reports describe the area as a meadow at least since the 17th Century. Roughly three-quarters of the vegetation remains native, with occasional supplementary sowing of wild flower species helping to maintain diversity. Non-native sheep graze extensively but sustainably, and hay is hand-cut only after nesting birds have fledged. For over a decade, no biocides or inorganic fertilizers have been used, resulting in healthy soil with good nutrient levels and biological activity, although minor compaction from livestock and erosion are evident.

The ecological community is imbalanced. Large predators are absent throughout the UK, leaving only meso-predators such as foxes and badgers in their place. This has led to Roe deer overpopulation, visible overgrazing, and reduced habitat complexity. The herbivore assemblage is also incomplete, lacking original bison, elk etc. Birdlife is limited to a handful of common resident species, with migratory visitors increasingly rare.

Overall, Earnshaw Wildmeadows retains some naturalness but suffers from depleted functionality. Its management system maintains some conservation values, aiming to balance sustainable grazing, biodiversity-friendly practices, and soil stewardship, though the loss of species and fragmentation continue to undermine resilience.

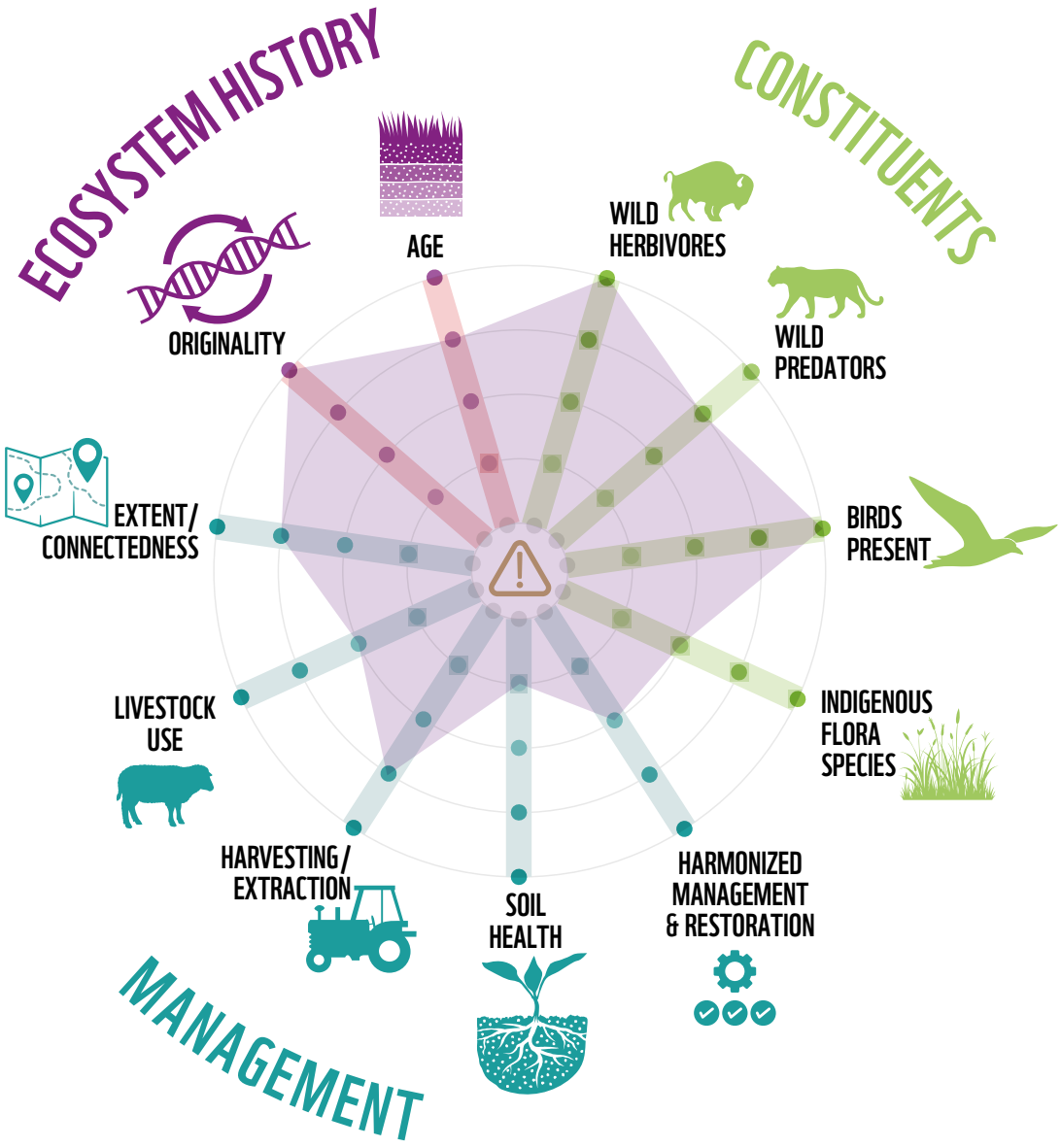


Figure 6: Naturalness spider chart for hypothetical grassland Dagoz Ridge Plains

Hypothetical Grassland: Dagoz Ridge Plains

Dagoz Ridge Plains run along the southern portion of the East African Rift Valley. They form a rugged sweep of savannah dating back at least 250 years. Although somewhat reduced in size and partially fragmented due to some residential property development to the West, much of its ecosystem function remains as a water table and source of pollinators for important agricultural centres nearby. Whilst there are some issues with invasive weeds, about half of the remaining flora is still native. Non-native sheep and goats graze extensively with some coexistence measures in place but without sustainable grazing plans. There is no large-scale grass harvesting; instead, small-scale gathering of fungi and medicinal plants is practiced sustainably.

Ecologically, the plains support an intact and abundant assemblage of native herbivores, with hyena, leopard and cheetah also present at reasonable densities, though some key species such as lions are missing. Birdlife remains diverse and thriving, with both native and migratory species occurring in abundance. Soil shows worrying signs of decline. Biocides are used sporadically, and poor biological activity and clear evidence of compaction and erosion all point to slow, long-term degradation.

While the grassland retains much of its naturalness and functionality, its management system overlooks certain core qualities of conservation value and risks gradual decline despite its relatively intact wildlife communities.

Identifying the importance of grasslands and savannahs from a cultural perspective

Prioritisation also needs to consider the people who live in and use virtually all the world's grasslands; their status and any threats that they face. Precise data are unavailable, but most grasslands and savannahs are occupied, with governance varying by country. In some, the majority is owned by the state and users lease land or occupy it without tenure security, in others, the majority is in private hands. For the purposes here, four main categories of cultural use might be identified:

- **Hunter-gathering**: mainly Indigenous peoples who survive partly or entirely by hunting and collecting wild foods, with examples including the Hadza people of northern Tanzania[429] and the San people of the Kalahari.[430] Most hunter-gatherer societies live in forests. The area of grasslands and savannahs used is unknown but likely to be relatively small and shrinking. However, many livestock herders and farmers use hunter-gatherer strategies as a supplementary or emergency source of food, greatly expanding the total area affected.

- **Nomadic, semi-nomadic, transhumant and other forms of mobile livestock rearing**: pastoralists who move during the year, either between fixed winter and summer sites or more generally. Global population estimates differ, many are around 30-40 million, mainly in Central and East Asia and the Sahel in Africa,[431] but other estimates say over 200 million.[432] Pastoralism takes place on about 25% of the Earth's land surface,[433] but figures for grassland have not been found. Numbers are falling,[434] due to government policies to encourage or enforce permanent settlement,[435] and to climate changes such as increased drought.[436] However, as climate change impacts settled farming, it is possible that mobile strategies may re-emerge in some areas.

- **Settled livestock rearing**: ranchers and livestock farmers who occupy a single piece of land year-round (although sometimes moving herds seasonally within their land). Ranches are generally large-scale and are found mainly in temperate regions of the South American Pampas and Campos, western United States, prairie provinces of Canada and Australasia. Smaller livestock farms on grass are found in all continents except Antarctica. Ownership is dramatically skewed with 1% of the world's farms now occupying over 70% of farmland[437] and numbers of small farmers continue to decrease.[438]

- **Non-food-producing uses**: nature conservation, sacred sites, tourism or areas managed for ecosystem services. Coverage of grasslands in protected areas ranges from 31% of flooded grassland and savannah to 4.5% of temperate grassland, savannah and shrub (slightly outdated figures).[439,440]

Uses are not all mutually exclusive. Many people practise a mixture of transhumance and hunting; some protected areas permit or are even based around transhumant pastoralists,[441] and tourism often coexists with other uses. There can be tension and clashes between different users, such as farmer-herder conflicts in sub-Saharan Africa.[442]

Identifying importance of grasslands from an ecosystem services perspective

The other ecosystem services from grasslands play important roles for both local people and, frequently, for people living further away. Considerable efforts have been put into measuring grassland ecosystem services,[443] although detailed data are still lacking. A global analysis recently mapped 14 critical natural assets at a global scale and for all terrestrial and marine ecosystems.[444] Remote sensing offers opportunities for some ecosystem services, including forage provision, climate regulation, location of watersheds and primary production,[445] allowing mapping on a global level. Many others require field research or interview, so that any global or national prioritisation system will inevitably rely on inclusion of a relatively small number of ecosystem services at the present time, at least in terms of information at any level of detail. Table 2 gives an indication of major data sources for key ecosystem services.

Table 2: Sources of information for mapping ecosystem services

Ecosystem service	Major source of information			
	Global mapping	Remote sensing	Field research	Interviews
Food provision				
Water provision				
Raw materials				
Genetic resources				
Medicinal resources				
Climate change regulation				
Disaster risk reduction				
Water flow regulation				
Erosion control				
Soil fertility				
Pollination				
Pest control				
Cultural and amenity				

Compiled by the authors.

If food security is also included in any prioritisation approach, this would focus on:

- **Areas important for raising livestock**:[446] perhaps differentiating different species of livestock and extensive or intensive production (some of these will also have wildlife interactions).
- **Areas converted to crops**:[447] differentiating between a range of crops and, importantly, cropland devoted to livestock fodder.
- **Land conditions**: particularly soil fertility, erosion, compaction, etc.
- **Climatic conditions** including likely changes in the medium term.

Presenting the results of prioritisation exercises

There is no single set of priorities, which depend on perspectives and needs. Presentation of results can therefore take a number of forms:

1. **As different layers on a map:**
   - Biodiversity importance (e.g., Red List species and ecosystems, Key Biodiversity Areas, AZE sites).
   - Ecosystem services (e.g., carbon stores, important surface and groundwater sources).
   - Cultural importance (e.g., territories of nomadic pastoralists, Indigenous peoples, areas of extensively managed ranches).
2. In a **matrix approach** using a scorecard, collecting key data on area and size and then rating each grassland against a series of values on a four-point scale, with agreed criteria for when a combination of scores makes the grassland a priority.
3. Some kind of **individual assessment system** (see example in Table 1).

SOLUTIONS: PATHWAYS TO ADDRESS THREATS

What kind of grassland and savannah biome do people want?

Key points:

- A mixture of conservation, sustainable management and careful restoration – protect, manage, restore – is needed to ensure a healthy grassland and savannah biome.
- A mosaic approach, where different values are prioritised across a landscape, is needed to supply everyone's wants and needs.

Policy entry point:

- A wide range of solutions to protect and restore grasslands are available and need to be elevated at global level, particularly in the three Rio Conventions, the UNFCCC, CBD and UNCCD.

One of the challenges in addressing current problems of grassland degradation and loss is that different actors have very different visions for what constitutes a healthy biome.

Many different views are valid and need to be respected but may not all be achievable on a single plot of land. For many farmers in Western Europe, "improved pasture" is probably an ideal, planted with non-native grass species and regularly treated with artificial fertilisers that can maximise productivity and extend the grazing season. A pastoralist in East Africa will probably prefer native grassland and savannah ecosystems, albeit with predators of livestock under control and wild herbivores not so numerous that they are in competition with domesticated species. For a conservationist in North America, native vegetation with a healthy and balanced population of herbivores and their predators might be the most desired option, although rangeland with livestock and wildlife is often an important option since, if grazed sustainably, it helps maintain grasslands in healthy condition and is important to keeping grasslands intact. Grassland adapted species vary in their ecological needs; a study of grassland birds in Europe found that a mixture of grazed and ungrazed grassland is needed to support the full range of species.[448]

Several factors influence societal choices about grassland, and even apparently straightforward options may be more complex than at first sight. A narrow focus on maximising livestock productivity has reduced many other benefits and often led to a deterioration in ecosystem health. For many reasons, including health, food security and climate change mitigation, a reduction in global meat consumption is needed.[449,450] But many grassland conservation projects encourage a mix of livestock and wild herbivores and some of the poorest people in the world are small-scale livestock herders; would a reduction in meat consumption have perverse impacts? Perhaps not, the highest environmental costs come from intensive systems,[451] so pastoralists may be less affected if overall meat consumption decreased. On the other hand, our growing knowledge of zoonotic disease risks has shown that there are arguments for separating livestock from wild species,[452] which is the opposite of many rangeland conservation programmes. A move back towards "wilder" grasslands and savannahs has multiple benefits for climate, land health and water quality.[453] Strategies need to be made on a case-by-case basis, in full consultation with all relevant actors.

Two complementary approaches will help address differences in values across actors in grassland conservation. First, to work with all types of land management to integrate wider environmental considerations into existing systems. Secondly, to recognise that supplying a full range of goods and services usually requires a carefully planned and negotiated mosaic approach,[454] with areas set aside to prioritise different needs such as food production, ecosystem services and biodiversity. Agreeing the mosaic is usually a complex process, particularly when multiple land managers are involved.[455] By implication, not everyone will get their way, all the time; future developments on grasslands and savannahs will be a matter of negotiation, trade-off and compromise.[456]

Protect, manage, restore

The triple approach of "protect-manage-restore", first coined by WWF in the 2000s, has been taken up in spirit by many institutions. UNCCD has a similar framing to "*avoid, reduce and reverse*" land degradation and World Resources Institute (WRI) has "*produce, protect, reduce, restore*", which acknowledges the need to produce more food on less land.[457] The boundaries between the various forms of management are not hard-edged; more than one can and often does take place in a single area. But they usually exist within quite different policy frameworks, involve different stakeholders and have different funding models and timescales.

Protected areas and OECMs are key tools for maintaining natural grasslands, particularly those with wild herbivores and carnivores

Protect

The first is to identify areas particularly valuable and/or threatened in terms of their biodiversity and other ecosystem services, and to agree restrictions on use compatible with maintaining their natural values over time. Under the auspices of the Convention on Biological Diversity (CBD), countries have agreed a target to set aside 30% of land and ocean into protected and conserved areas by 2030 (30x30), which will include many grasslands. The best-known approach is through protected areas such as national parks and nature reserves. Here nature conservation is the priority, although within this a wide variety of approaches can be followed, from strict protection to the maintenance of living landscapes where people carry on traditional lifestyles that support biodiversity.[458] Governance is also varied, management by various arms of the state, or by private owners, or Indigenous peoples and local communities, with pluralistic models ("co-management") becoming increasingly popular.[459]

More recently, the CBD has recognised another model, other effective area-based conservation measures or OECMs (also called "conserved areas"). Here the primary management aim is not necessarily or usually to conserve biodiversity, but this comes as a secondary or accidental result of management. Watershed protection areas, military training grounds, Indigenous territories can all on occasion legitimately be recognised as OECMs.[460] The extent to which some ranches or pastoralist areas can be recognised as OECMs is still being worked out and will need to be decided on a case-by-case basis. The CBD has also made tentative moves towards recognising some Indigenous or tribal territories outside of either protected areas or OECMs as counting legitimately towards global targets for area-based conservation.

Alongside these "formal" types of area-based conservation there are others – such as ecological corridors, often agreed by negotiation with landowners but sometimes inscribed into law – or areas to maintain ecosystem services. Connectivity is critical to conservation particularly of wide-ranging mammals[461] and the removal of linear barriers may be important.[462,463] These less formal approaches to area-based conservation often grade into what we might consider management or restoration.

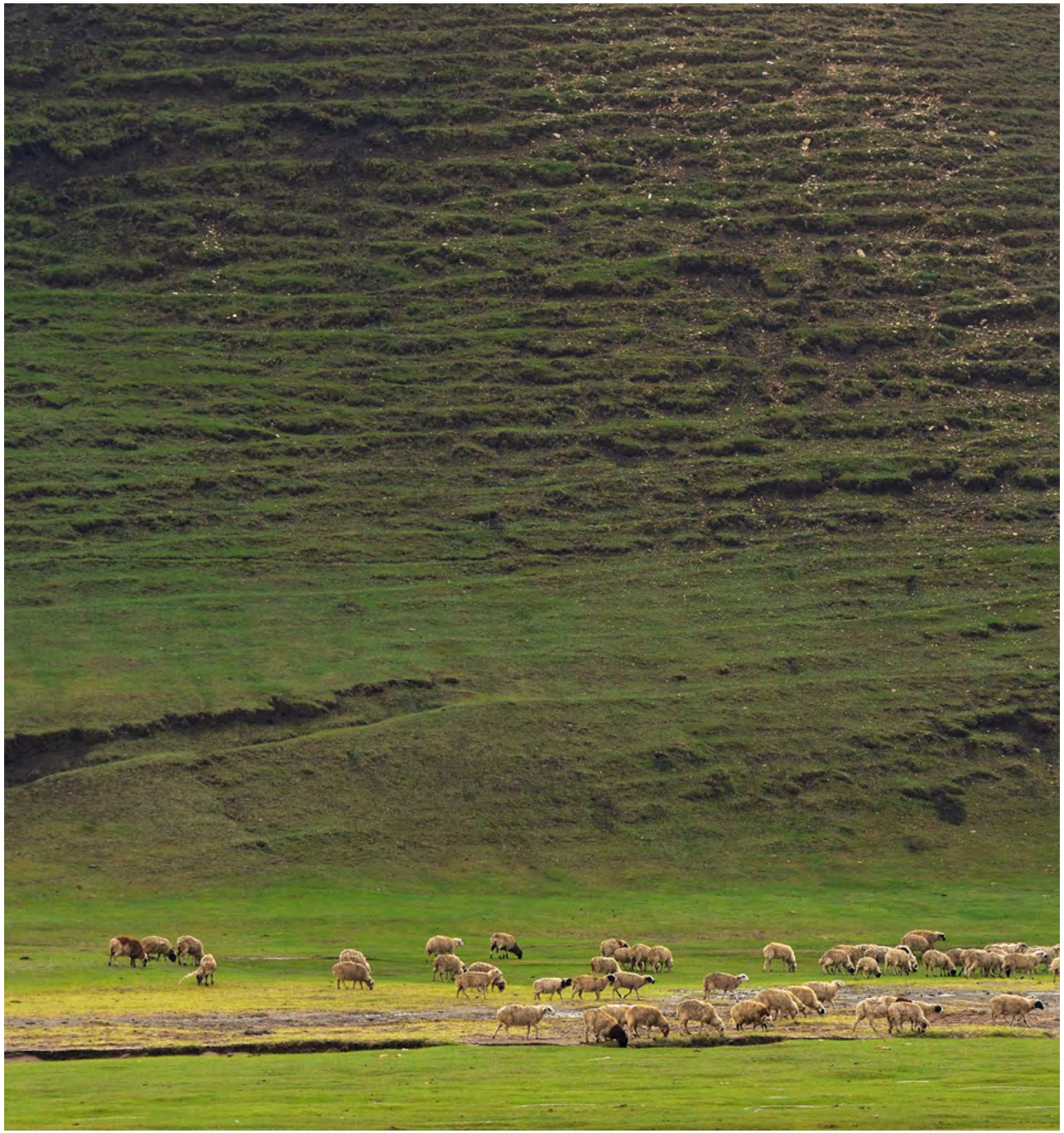
Protected areas and OECMs are key tools for maintaining natural grasslands, particularly those with wild herbivores and carnivores.

The Site of Special Scientific Interest (SSSI) designation protects 68% of the UK's remaining grasslands through regulation of activities and financial incentives. Between 1960 and 2013, over 90% of SSSI grasslands were conserved compared to under 30% in non-protected sites.[464] In Kazakhstan, the government protected five million hectares of steppe which helped endangered saiga antelope increase from 50,000 to 1.3 million individuals between 2005-2022.[465] Legal protection of various sorts remains a key tool in sustainable grassland management.

There is good evidence that well managed and well-resourced protected areas are effective at conserving ecosystems and biodiversity.[466] But there are many examples where protected areas are failing, or partially failing,[467] and increasing their effectiveness is an urgent priority. Because OECMs are newer, with the OECM definition only agreed by the CBD in 2018, evidence of their long-term impact is lacking. But as countries scramble to meet global commitments, OECM numbers are rising quickly, and their success or failure will be pivotal in grassland conservation. Protected and conserved areas are increasingly applied within a human rights framework, especially in the case of Indigenous peoples where any changes within their territories can only take place with their Free, Prior and Informed Consent (FPIC).[468]

Manage

Protected and conserved areas will remain a minority of the biome; biodiversity and other ecosystem services also need to be conserved in lands managed for other purposes, usually livestock. Different livestock management practices have impacts on ecosystem services, including by altering grazing patterns, wet and dry season grazing, removal of invasive species, changing livestock species mix, agricultural simplification[469] and many more.[470] This often relies on policy changes well away from the ecosystem, such as removal of perverse agricultural subsidies that support over-stocking, addressing the underlying causes that encourage people to build large herds, including socio-cultural pressures, and visionary leadership from the global food industry. Reversing policies that have been building since the 1940s will not be easy or necessarily quick, but changes are coming.



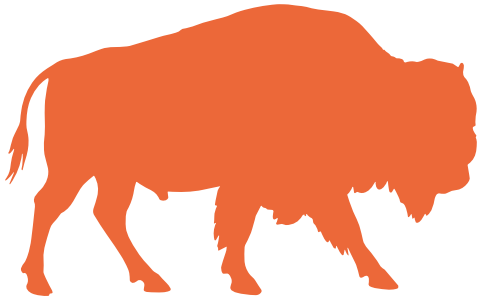
Livestock grazing substituting for wild herbivores

Livestock grazing is frequently used as a conservation tool, for instance in North America and Europe.[471,472] As wild herbivores decline, the biomass of livestock has increased. Cattle are the most significant mammal species globally by biomass, weighing ≈420 Mt (outweighing humans at ≈390 Mt) and the mass of sheep outweighs all wild mammals combined.[473] But can livestock be used as a replacement to wild browsers and grazers? Partially, but there are gaps, and recent evidence suggests that livestock grazing is frequently negative for ecosystem function.[474]

Different grasslands have different evolutionary histories and herbivore assemblages. When considering which livestock is best suited to a particular grassland, it is important to consider which species of grazers evolved there. Each species and breed of livestock has different dietary preferences and grazing patterns. Moreover, management practices (sustainable stocking rates, etc.) have a significant impact on whether livestock fulfil similar functions to wildlife.

Barring Australia, most grasslands have evolved with some species of bovid. Cattle are often confined to a limited area and are less selective grazers than sheep,[475] taking a haphazard amount of many different grass and forb species. At lower densities and when they are allowed to range they can be more selective. They tend to avoid areas of dung, so the grasses here remain longer and are fertilised. This creates a greater variety of microhabitats for wildlife, a healthier ecosystem and more reliable ecosystem services. In sub-Saharan Africa, sustainable semi-nomadic pastoralism with mostly local cattle breeds can mimic many of the soil-building, biodiversity boosting processes of wild herbivores.[476] In Canada's temperate grasslands, light to moderate long-term cattle grazing enhances ecosystem carbon storage by almost 9%.[477]

By comparison, sheep evolved in the rocky, dry grasslands of the Middle East. They are relatively unselective grazers and eat grass down to the base of the stem. Sheep cause major degradation to soil and hydrological processes in grasslands where they did not evolve such as in much of Europe.[478] In these cases, long-term sheep grazing reduces species diversity and their removal results in reduced degradation and more nutritious, palatable, digestible and decomposable plants but recovery takes decades.[479] When their



Native wild herbivores are often better adapted than livestock to maintain natural grasslands and survive local environmental conditions

environment is deficient in certain minerals, sheep can predate ground-nesting bird eggs.[480] The overstocking of sheep and use of many protected areas for sheep[481] are now major problems.

Minor changes in policy can make a big difference. In the UK, it is planned that farmers will be paid to remove livestock from intensive grasslands at certain times of the year and from unproductive lands next to inland waters,[482] although this is being resisted by farming lobbies.[483]

Utilising wild herbivores

Native wild herbivores are often better adapted than livestock to maintain natural grasslands and survive local environmental conditions, differing in grazing intensity and form, choice of food plants, trampling pressure and other factors. Wild herbivores create microhabitats through irregular and shifting herbivory. Replacing livestock with reared or the managed culling of wild herbivores can often reduce degradation and boost ecosystem services. Use of wild species has strong links to cultural traditions and native identity, like reindeer[484] or caribou[485] in the boreal region. Bison were driven almost extinct in North America, at least partly to remove First Nation groups by destroying their resources and encourage European settlement;[486] bison restoration is of huge symbolic importance.[487] And it is good for the grassland.[488]

Countries like Namibia have a growing legal native herbivore market. Wild meat is seen as an adaptation strategy to climate change.[489] In Australia, a million kangaroos a year are shot and used for human and animal food and for leather. Experts believe far more could be taken sustainably and kangaroos survive the climate better than cattle, but there is resistance amongst consumers and many are now culled and left to rot in the field.[490]

This example highlights a challenge of this approach. Substitution of wild herbivores for livestock is usually good for grassland health, if stocking rates and offtake are managed, but often needs to overcome cultural barriers to eating wild food. Livestock farmers may also be resistant to change. (Conversely, elsewhere over-use of wild meat is catastrophic for animal populations,[491] and addressing this requires careful and nuanced policies.)[492] There are animal rights issues, some people in Australia oppose killing kangaroos.[493] While sustainable use of wild meat is an important option to explore, it needs careful policies, legislation and enforcement, along with careful socialisation.

Managing for climate change

Linking agricultural support to policies that balance livestock production with carbon management and grassland health are emerging around the world. Improved grassland management has the potential to increase SOC substantially in many countries,[494] although some well reported studies appear to have overstated the gains[495] and results are very context specific, so that the reverse can also occur. Carbon management may mean adapting livestock management according to conditions.[496] Evidence suggests that increasing SOC can also increase productivity and resilience, although there are challenges in persuading people to change long-held management practices.[497] Changing from continuous to rotational grazing has been reported as increasing SOC significantly,[498] as does a switch from high to moderate grazing,[499] and temporary grazing exclusion has proved beneficial for both SOC and vegetation health in China.[500] But policies need a holistic approach. Fire suppression to increase woody growth in the Brazilian Cerrado savannah led to a decrease in plant and ant species richness,[501] and probably also increased the risks of larger fires in the future.

Alongside carbon management, increasing attention is focusing on reducing methane emissions from livestock production on grasslands, including through changing forage allowances[502] and other feeding strategies.[503]

Climate change strategies for grassland therefore need to be rooted in knowledge about local conditions, starting with a thorough grasp of likely effects on grassland and people, then selecting strategies that cover, as necessary, building resilience, restoring lost or degraded grasslands including, where necessary, translocations and conservation genetics, and finally working hard to avoid human maladaptation.

Well in advance of government initiatives, many pastoralist systems are already being adapted. They use a mix of traditional and upgraded approaches to integrate mobility, vegetation management, targeted interventions and improved governance to increase carbon storage and adaptation.[504]

Reducing intensity of agriculture can also help to restore grasslands. In Finland, farmers were subsidised to enrol 5-15% of their farms in an environmental fallow scheme, increasing vegetation cover from 64% to 90%.

Restore

Serious levels of grassland degradation mean that restoration strategies are increasingly important. There is experience to draw on,[505] but still much to be learned. Many current efforts focus on recovery for agriculture, reduction in soil erosion, control of invasive species and fire management. Even within conservation there are very different objectives. In North America, aims for grassland restoration range from the still theoretical Pleistocene rewilding, i.e., reintroducing predators similar to those lost in recent prehistory,[506] to reintroducing bison,[507] or general efforts to boost herbivores[508] or more modestly to reduce erosion and restore healthy grass cover. Other restoration is motivated by recovery of ecosystem services, particularly carbon.[509] There is a common belief that grassland restoration is faster than for forests, but regaining anything like a natural grassland ecosystem, above and below ground, often takes longer and is likely to be only partially successful.[510]

Restoration takes two broad forms: creating conditions to allow natural regeneration; and more active planting, geoengineering or reintroductions. Both are predicated on the assumption that future management will differ in ways that remove or adjust whatever was causing the degradation in the first place, otherwise efforts will be wasted.

Decisions are needed about the trajectory of restoration. In the past, restoration aimed at linear succession to "climax vegetation", but advances in nonequilibrium ecology and resilience theory suggest a more dynamic grassland, with multiple states persisting as self-organising systems.[511,512] Furthermore, environmental change now means that ecosystems can often no longer return to their pre-disturbance state and that new dynamics – "novel ecosystems" – are emerging instead and where appropriate can be leveraged for biodiversity conservation.[513]

Where residual natural vegetation remains, first steps are usually assisted natural regeneration as a quicker, easier and cheaper option. This can include removing pressures such as invasive species, regaining natural functions and managing disturbance factors like fire. A combination of mega-faunal extinctions and landscape fragmentation has left many parts of the world with an unstable relationship between forest and grassland. When traditional management has to some extent acted as a substitute,[514] its decline can create an ecological imbalance that needs to be addressed.

Removing pressures, particularly the exclusion or reduction in livestock or the control of unnaturally high populations of wild herbivores (e.g., in the absence of predators), is the commonest form of natural grassland regeneration. Numerous studies show vegetative responses, often followed by related increases in insects, birds[515] and other species. Increased vegetation diversity helps to reduce soil erosion.[516] Studies in China found that grazing exclusion quickly increases above and below-ground biomass and SOC, soil water retention, nitrogen and phosphorus,[517] but the resulting boost to plant diversity declines again over time,[518] suggesting some grazing is beneficial.[519] Complete grazing exclusion can also lead to takeover by scrub or invasive species[520] and a decline of native vegetation.[521] This type of restoration therefore generally involves temporary exclusion[522] and/or reduced stocking levels.[523] The use of temporary cattle corrals (mobile bomas) in Africa to protect livestock at night has also been shown to concentrate nutrients, helping form woodland glades.[524]

These management changes have economic impacts for herders which need to be addressed, although serious overgrazing often reduces productivity so that regaining a more natural balance can be win-win. The key to success in restoration is usually building local support. Local control is important, in China decentralising budgets and authority to local governments increased the success of grassland conservation.[525] Peer-to-peer learning between communities is an important factor in success, particularly if this incorporates aspects of traditional management, such as the revival of the *hima* system in the Middle East.[526]

Control of native herbivores is more complex, over-abundance can lead to unnaturally low levels of forest and overgrazing of grassland, while their decline creates scrub and woodland encroachment, a major cause of grassland loss, e.g., in parts of central and eastern Europe. Getting the right balance in places where top predators are absent often means long-term management by humans.

Reducing intensity of agriculture can also help to restore grasslands. In Finland, farmers were subsidised to enrol 5-15% of their farms in an environmental fallow scheme, increasing vegetation cover from 64% to 90%.[527] A switch to low input or organic systems is an important component of many restoration projects.

Disturbance factors in grassland include wind, rain, snowfall, flooding, erosion and particularly fire and soil disturbance due to human or livestock activity. When degradation has passed a certain point, various forms of soil stabilisation or protection may be needed to help kickstart restoration, including shelterbelts and forest patches.[528] In wet grasslands, restoration of natural flooding regimes may be important to regain biodiversity.[529] Many grasslands are fire adapted, with processes like seed germination reliant on frequent "cool fires", usually started by summer lightning or intentionally as part of Indigenous fire practices, which suppress much of the tree growth and result in a classic savannah of open grassland and a few trees. Fire suppression, such as that caused by heavy grazing removing the fuel load or by government policy banning use of fire, can lead to scrub and tree encroachment and then eventually larger and more damaging fires. Adjusting fire regimes, including through early dry season burning has been found to be beneficial, because fires are generally smaller and less intense, and thus lead to less emissions overall.[530] But while there are millennia's-worth of experience in burning among local people, current climate change means that we may need to revise approaches; everyone is learning.

Finally, when changes have been dramatic or longer term, more active methods may be needed, if natural seed banks have disappeared, invasive species have taken over an area, or due to increased extremes in more arid systems. Grassland restoration can include active irrigation in drylands, construction of shelter beds or earth banks to protect newly restored areas from wind, digging of half-moons, and active reseeding. Where invasive species are a serious problem, these first need to be cleared, then a seedbed prepared followed by seeding or planting and aftercare.[531] Restoration programmes may also choose to plant native species to speed up recovery, such as the miles of motorway verges that have been planted with native flower species in Europe. Seed sources include commercial mixes, seeds collected from natural meadows or hay from the latter (in temperate regions),[532] or topsoil transfer, which is often effective in the tropics.[533] Restoration activities may include rebuilding or even reintroducing populations of animal species that play a role in maintaining a healthy grassland, for example reintroduction of bison in North America is expected to significantly increase CO_2 uptake.[534]

Active restoration also often speeds up the process of recovery of ecosystem services. Research found, for instance, that reestablishment of high plant diversity on abandoned agricultural land greatly speeded up the process of carbon sequestration in underlying soil.[535]

None of these approaches are enough on their own. A planned, carefully negotiated and judicious use of protection, management and where necessary restoration can in combination help maintain and regain healthy and functioning grassland and savannah ecosystems.

ENABLING CONDITIONS AND POLICY RECOMMENDATIONS

Positive changes take time and effort. Steps include a careful mix of legislation and policies, often coupled with financial incentives (e.g., removal of perverse subsidies and direct support for beneficial practices) and capacity building at local level.

Information is critical and still often lacking, both on composition and status of grasslands and on many details of sustainable management and restoration. Below, we list some outline recommendations.

- **Support national implementation of UNCCD Land Degradation Neutrality commitments to conserve and restore grasslands and savannahs and the recent advances targeting rangelands and pastoralism**. Elevate grassland conservation in key international biodiversity, climate, and land degradation agreements and action plans. The International Year of Rangelands and Pastoralists (IYRP) in 2026 presents an opportunity for strategic, unified action.
- **Consider grasslands in an integrated manner across all three Rio conventions** (UNCCD, UNFCCC and the CBD) to break silos and maximise effectiveness:
  - Reduce and where possible eliminate land use transformation and change in native grasslands, focusing efforts on the most valuable grasslands from biodiversity, ecosystem services, and cultural perspectives (CBD KM-GBF, Target 2 and Target 3).[536]
  - Support dedicated area-based conservation with sustainable financing for grasslands to support ecosystem health (Target 3). Secure long-term funding for protected areas to support implementation of management plans. Invest in baseline assessments, mapping, and monitoring of grasslands to identify key areas for targeted protection.
  - Address counterproductive policies and investments that contribute to land use change and degradation by promoting conversion of lands for crop production or other uses.
  - In the US, crop insurance subsidies remove the risks associated with farming marginal lands such as converted grasslands, incentivising crop expansion on those lands. To protect intact grasslands, the US Congress should strengthen Sodsaver (a provision created to address the impacts of crop insurance that has driven grassland conversion) by making newly cultivated native sod acreage ineligible for any crop insurance premium subsidies for 10 years, and by expanding Sodsaver's native grassland protections nationwide.
- **Address complex problems of both overgrazing and under-grazing**, including through removal of perverse policies and incentives where necessary. Support assessment of current agricultural practices to identify barriers limiting sustainable approaches and develop clear guidance to advance actions to mitigate challenges. Advance conservation policies and programmes to support more sustainable grazing and farming while recognising the rights of Indigenous peoples, and local communities.
- **Develop comprehensive programmes to address invasive species in grassland** in cooperation with local users, through a combination of preventative measures, early detection and rapid response, and targeted control strategies.
- **Remove perverse incentives for afforestation with exotic species**: particularly under climate mitigation initiatives. Many carbon offset programmes and afforestation policies mistakenly classify native grasslands as "degraded lands", making them eligible for tree planting that disrupts ecosystems.[537] Policy reforms should ensure that climate mitigation strategies recognise and protect native grasslands, prioritising restoration and sustainable management.
- **Support pastoralist and transhumant communities, their culture and production systems**, including through participatory land use planning integrating nomadic herding, transhumance and mobile pastoralism with other land uses (KM-GBF, Target 1).
  - Create multi-sector mechanisms that include Indigenous peoples and local communities in restoration planning and governance to foster restoration efforts that are culturally

appropriate, integrate local knowledge, and advance mutually beneficial outcomes.
    - Recognise and respect the role of traditional governance structures and practices of Indigenous peoples and local communities for managing grasslands in ways that build resilience to extreme events.
    - Recognise and enable pastoral mobility as a strategy for climate change adaptation and sustainable land management by Indigenous peoples and local communities.
    - Implement capacity building for Indigenous peoples, local communities, farmers and herders to upgrade and improve sustainable livestock grazing and management. Invest in decent employment and livelihood opportunities, especially for women and youth – e.g., through entrepreneurship, enterprise, smallholders, and family operations – to ensure inclusive, equitable and decent opportunities to generate income, including outside of livestock grazing.
    - Promote participatory frameworks for land planning, governance and management of grasslands, fully including pastoralists and other users in decision-making.
    - Recognise the role of pastoralist women and their contribution to sustainable land management and production, promoting gender-sensitive approaches, supporting their empowerment and facilitating meaningful participation in decision-making.

- **Secure tenure for smallholder farmers and pastoralists**, many of whom are facing pressure from powerful landowners or governments. For transhumant pastoralists, this includes secure passage between seasonal grazing and access to water for livestock. In many cases, governments will need to mediate between different groups to reach compromises on tenure and access rights.

- **Recognise grasslands as important and stable carbon stores** and afford them greater priority in climate negotiations (UNFCCC) and inclusion into Nationally Determined Contributions (NDCs).[538] Assess the economic value and benefits of ecosystem services delivered through a shift to more sustainable grazing practices, such as soil carbon storage, climate change adaptation potential, and diversity of pollinator communities.

- **Facilitate research, monitoring and implementation of restoration projects on degraded grasslands**, to recover biodiversity, ecosystem services and opportunities for sustainable use (UN Decade on Ecosystem Restoration and KM-GBF Target 2). Address research gaps in grassland restoration, with a focus on the adaptive requirements of different grasslands. Invest in research and demonstration studies to foster effective science- and evidence-based initiatives that benefit nature and people. Ensure inclusion of Traditional Ecological Knowledge (TEK) and culturally appropriate practices by engaging the communities where projects will take place during the design process. Establish long-term monitoring and learning sites to track consistent indicators and ecosystem services to understand changes over time, e.g., the implementation of a global monitoring framework.

- **Restore large, wild herds** moving over extensive, connected and diverse landscapes (UN Decade on Ecosystem Restoration).
    - When appropriate, develop market opportunities for nature-based tourism in rewilded grassland landscapes.

- **Prioritise investments for highest value outcomes and encourage innovation**: Payments for results over practices similarly can make optimal use of resources while giving farmers freedom to choose their practices. The high cost of measurement and verification for measuring outcomes is a current barrier, and a continued focus on making Monitoring, Reporting and Verification (MRV) more accessible and affordable is needed. Many government programmes have limited resources, both in terms of budgets to fund conservation and staff capacity for management and outreach. Programmes that do not differentiate between high and low conservation-value grasslands risk spending limited resources on less important grasslands. Further refinement of the High Conservation Value approach[539] for grasslands would be warranted to efficiently integrate biodiversity into decision-making.

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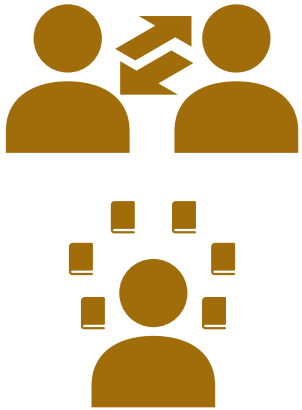
- **Adopt a cohesive national policy framework and robust ecosystem classification system to successfully conserve and restore grasslands**. Such a framework would consider grasslands' carbon sequestration potential, emissions arising from conversion, and roles for biodiversity protection to avoid targeting old-growth and other high conservation value grasslands as sites for afforestation.

- **Increase investment in tracking conversion**: The implementation of regional monitoring programmes can identify remaining intact grasslands/habitat and conversion frontiers, so that resources can be directed to those areas.[540,541] User-friendly tools and platforms that aggregate land cover data from different agencies or universities can simplify the analysis and increase the use of relevant information that is already gathered and processed.

    - Baseline assessments are essential for countries to set targets and monitor progress, and tools exist to help.[542] This requires improving the mapping and data related to grassland degradation and creating standardised indicators for monitoring grassland condition.
    - The development of improved guidance and frameworks to assess and reward avoided grassland conversion and alignment of those protocols with SBTi/FLAG, SBTN Land Targets, the GHG Protocol and other protocols are needed to further incentivise keeping grasslands intact.[543] Relevant national agricultural agencies should improve data and support systems that enable tracking collectively across whole landscapes as well as at finer scales (county/farm scale). Countries/agencies should provide leadership in creating consistency in data collection that furthers the state of science, ensuring quality and transparency in data and model integration that incorporate the factors that drive land use change.

- **Dramatically expand more direct-to-producer, -producer organisation, and -producer cooperative financing programmes, prioritising sustainable land management**. Financing is essential to support improved grassland conservation and sustainable management. Governments and private sector finance entities should put producers in direct connection with (and derisk) sources of finance for grassland conservation, climate smart agriculture and sustainable land use investments via producer entities. To drive this change, private sector finance institutions, NGOs and governments should:

    - Create processes to advance appropriately sized grants alongside larger current grant approaches to provide funding at a scale that producer-led organisations can manage. They must address hurdles that make financing hard to access, including high interest rates, short servicing periods, organisational capacity challenges, and complex procedures, and must ensure loans are sized to allow farmers to access machinery.
    - Make soft loans more available, especially to support sustainable agriculture practices. Many small farmers and ranchers do not qualify for conventional loans. Soft loan providers often have environmental and social criteria that borrowers must meet, encouraging them to adopt sustainable practices.
    - Develop blueprints of producer organisation-based direct public and private finance models, impact investing, and patient capital mobilisation that drive positive impacts at the landscape level.
    - Explore profit-sharing models to ensure equitable outcomes for producers and develop guidance on how to build systems that aggregate and scale up rural enterprises to better enable blended public-private financing of diverse investment opportunities.
    - Empower and educate consumers on how their purchases have impact on the land and the people who manage it.



- **Prioritise peer-to-peer networking and system knowledge transfer, as well as financial investment in technology and capacity building to support their benefits at scale**. Research has highlighted the value of producer networks in supporting producers[544] to innovate and adapt in the face of new challenges and opportunities. To do this, governments should consider existing networks and institutions. In France, there is a tradition of agricultural competitions which have prestige among farmers. France capitalised on this pre-existing institution to launch a Flowering Meadows competition to encourage grassland conservation.[545] To prioritise and invest in knowledge transfer and rancher networking, governments and the private sector, along with collaborating stakeholders, must:
  - **Increase investment and grassland management programming that prioritises and boosts support for extension and producer networks as responsive and adaptive structures**. Governments, universities, corporations and NGOs should increase investment in technical assistance and educational support that engages producers, producer networks, and adaptive learning. A critical pathway is virtual networking and trainings. It is important to have producer-to-producer knowledge transfer about system change, cooperative-to-cooperative knowledge transfer and networking and co-use of equipment to enhance technology transfer, and to support farmers, ranchers and pastoralists to see, learn and adopt appropriate policies.
  - **Support improved data collection and information sharing to enable monitoring of producer supply chains and give producers' access to markets that support sustainable grassland management and conservation, including traceable and conversion-free commodity supply chains.** To support producers in this dynamic, the public and private sectors should:
    - Support the development of transparent systems for mapping, monitoring and publishing data on the degradation and conversion of natural grasslands, forests and other natural ecosystems and associated commodities' production and supply chains. This should align with efforts by major consumer markets, such as the EU, and producer countries, to comply with emerging market requirements.
    - Develop farm-level supply chain traceability systems, with an emphasis on cost-effective technologies to enable independent smallholder ranchers and producers, smallholder associations and collectives to collect, manage and maintain ownership of data necessary for compliance with emerging market requirements.
    - Continue to generate stronger evidence on the impacts of sustainable grassland management systems, nutritional and environmental outcomes, and system resilience and to strengthen linkages between research, extension and producers.

THIS REPORT IS INTENDED AS A STRATEGIC INPUT TO UNCCD COP17. WE CALL ON GOVERNMENTS AND DONORS TO RECOGNISE GRASSLANDS AND SAVANNAHS AS KEYSTONE SYSTEMS FOR ACHIEVING LAND, CLIMATE AND BIODIVERSITY GOALS.

CASE STUDIES

The following case studies have been identified to illustrate different elements of good grassland management; from restoration of native herbivores, through good livestock management through to attempts at rewilding.

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REGENERATIVE WOOL AND RANGELAND MANAGEMENT, SOUTH AFRICA

© Equilibrium Research

SUSTAINABLE CATTLE RANCHING, MEXICO

© Julian Manrique - WWF Colombia

SAFEGUARDING OVERLOOKED ECOSYSTEMS IN SOUTH AMERICA

© Mark Jones / Wunambal Gaambera Aboriginal Corporation.

INDIGENOUS FIRE MANAGEMENT AND CARBON OFFSETTING, AUSTRALIA

© Equilibrium Research

RESTORING BISON AND INDIGENOUS CULTURE IN THE NORTH AMERICAN PLAINS

© WWF-US / Emily Vandenbosch

NATIVE RESEEDING PROGRAMME IN THE GREAT PLAINS OF THE UNITED STATES

© Equilibrium Research

ODER DELTA REWILDING AND NATURE-BASED TOURISM, GERMANY

© Juozas Cernius / WWF-UK

RESTORING COMMUNITY GRASSLANDS IN CHYULU HILLS, KENYA

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ALIANZA DEL PASTIZAL (GRASSLAND ALLIANCE)

REGENERATIVE WOOL AND RANGELAND MANAGEMENT, SOUTH AFRICA

Name	Eastern Cape Drakensberg Grasslands Biome[546]
Designation type / protective mechanism	Mixed production-protection-conservation landscape
Designation status	Began selective, regenerative grazing in 2021
Primary aim/s	Connecting fragmented protected areas with nature-positive rangeland corridors for wildlife Bringing production landscapes and local people into a more inclusive conservation approach Improving water source management in the 10% of South Africa that provides 50% of the country's water needs
Area (ha)	Aiming for 30,000 hectares incorporated into this landscape
Governance type	Mixed landscape

Management, restoration, protection mechanisms

The Eastern Cape Drakensberg Grassland initiative landscape consists of a patchwork of state-, communal- and privately-owned lands under various management objectives including protected areas, biodiversity stewardship sites, tourism, and livestock production and grazing areas. The landscape, part of the GEF-WWF Mega Living Landscapes project, overlaps with a large strategic water source area. The project aims to establish a new grassland national park on a portion of this landscape, on a strategic water source area, through a multi stakeholder engagement approach. Within this landscape landowners are voluntarily committing their land to stewardship agreements through arrangements with Eastern Cape Parks and Tourism Agency (ECPTA) and partners, such as WWF South Africa.[547]

Biodiversity values

Sheep, as selective grazers, have had a large impact on biodiversity here. Unsustainable, uninterrupted grazing, with no rest and recovery for the grasslands has degraded the area in the past leading to more prevalent fires and invasive species, etc. Caracal and jackal occasionally take sheep. In the past, this has led to predator persecution, but counterintuitively killing off an old pair of caracal or jackal ensures that younger individuals will take their place, these younger individuals are less reluctant to enter anthropogenic areas and are likely to result in greater sheep depredation.

The project now has 277 communal farmers implementing sustainable grazing, three commercial farmers practising regenerative farming, 9,927 hectares under conservation agreements, 108 ha cleared of invasive plants and human-wildlife conflict workshops conducted.

Human and ecosystem service values

As a wool buyer from the area, the H&M group is a key funder for this landscape. Assisting farmers with grazing plans to improve management practices is an incentive in and of itself. This is slowly improving grasses and water management. Animal health training and access to market support also incentivises local people to engage. Certification systems for sustainable livestock are now ensuring that farmers get a premium on the price per kilogram of wool.

The project has now equipped three grazing associations with fire-fighting equipment, vaccinated 3,500 sheep and has 67 community members in training for agri-ecotourism.

Key challenges

The project has identified four key challenges it aims to tackle: local communities do not benefit adequately from conservation; alien and invasive plant species are impacting biodiversity and using a significant amount of water; unsustainable land management practices (like overgrazing) are causing degradation; the landscape is fragmented and unintegrated. These issues all still exist in the broader landscape.

SUSTAINABLE CATTLE RANCHING, MEXICO

Name	Malpais de la Breña grasslands, Rancho el Ojo[548]
Designation type / protective mechanism	Ranch owned by the Saravia family, preserving the grasslands
Designation status	Began selective, regenerative grazing in 2021
Primary aim/s	• Sustainable cattle ranching and agave farming • Diversified livelihoods and economic options • Grassland restoration and rehabilitation • Improved water table management for livestock and wildlife
Area (ha)	Unclear
Governance type	Privately owned

Management, restoration, protection mechanisms

The Rancho el Ojo cattle once grazed freely across both the ranch land plots, and had full access to all the rocky, elevated areas that were not considered good grazing lands but were used for grazing anyway. The grasslands were totally degraded, there was almost no grass left but the cattle were eating enough cacti and supplementary feed for the business to function.

In 2020/2021, a colleague of Bildo Saravia (the owner and manager of the ranch) visited and suggested that the cattle and the land could be much healthier if portions of the elevated, rocky areas were left to rest. Bildo removed the cattle from this land for 18 months, he returned to a totally different ranch: the grasslands were recovering. Eight grass species had returned that were previously locally extinct. Bildo now applies this pasture regeneration method to all the Rancho el Ojo plots, allowing certain areas periods of recovery from intensive cattle grazing.[549]

Biodiversity values

Insects, birdlife and previously rare grass species are now returning to the plots. The entire ranch has greened.

Human and ecosystem service values

In the 2022 and 2023 dry seasons, there was a severe drought in the region. However, by then Bildo had been restoring the water table for a couple of years and unlike their neighbours, Rancho el Ojo's water table remained. At 30 inches of grass growth per year, Rancho el Ojo is a conspicuous green block in a landscape of overgrazed yellow. Bildo's neighbours are beginning to notice the difference: improved water management and green grasses returning to Rancho el Ojo. They are changing their minds about intensive grazing and asking about more sustainable management.

Key challenges

The Rancho Las Yucas plot, positioned close to a city, is threatened by housing development. The area is beautiful and many holiday homes are being built in the hills. Here, preserving the ranch also directly protects the grasslands from residential conversion. Threats from cartels taking large swathes of land and the industrialisation of crops like agave are increasing.

In 2012-2013, global demand for mezcal skyrocketed, leading to an alarming expansion of agave monocultures. These factors combine with rural depopulation and are weakening communities, ranchers and ranching culture.[550]

Eighty percent of Mexican land is owned communally, mostly by poor, rural communities ranching cattle on degraded, overgrazed grasslands. As these communities weaken, Bildo fears we are missing an opportunity to preserve culture, livelihoods and nature.

ODER DELTA REWILDING AND NATURE-BASED TOURISM, GERMANY

Name	Oder Delta
Designation type / protective mechanism	A landscape of protected areas
Designation status	N/A
Primary aim/s	Rewilding: restoring trophic complexity, allowing for stochastic disturbances and enhancing species' potential to disperse
Area (ha)	250,000[551]
Governance type	Mixed landscape

Management, restoration, protection mechanisms

Both Germany and Poland have recognised the social and ecological values of the Oder Delta landscape and set aside two-thirds of all land and water for nature conservation and rewilding. Under the rewilding framework, the goal for the area is to support wildlife to return to more natural densities and allow the ecosystem to self-regulate. To reach this goal, Rewilding Europe partners' interventions have focused on rewetting pastures; abandoning peat-cutting; restoring quality and connectivity of peat, wetlands and coastal areas; removing obstacles to enhance fish migration; restoring spawning gravels; anti-poaching; preparatory coexistence measures and human-wildlife conflict mitigation prior to the return of elk and increasing natural grazing to restore grasslands. These rewilding measures are running in parallel to support for sustainable development to enhance and generate new economic opportunities for local people.[552]

Biodiversity values

The Oder landscape forms a rich mosaic of terrestrial, marine and freshwater ecosystems creating an important stop-over site for migrating water birds using the East Atlantic Flyway. Over the course of the project, populations of lesser spotted eagle, osprey, white stork, black stork, eagle owl, Eurasian crane, aquatic warbler, whiskered tern, white-winged tern, black-winged stilt, great snipe, three harrier species and many other birds have stabilised. White-tailed eagles here now have the highest breeding density in Europe. Otter, beaver, bison, wolf, elk, grey seal, sturgeon, salmon and sea trout are also increasing in population and/or range.

Human and ecosystem service values

The Oder Delta has always provided provisioning services in the form of hunting and fishing. However, with loss of connectivity and habitat, unsustainable hunting and fishing practices, and more recent issues with industrial pollution and climate change, fish and game populations have been falling. Under the rewilding programme, hunting associations have adopted new and less disruptive hunting methods and fishers have agreed on no-take zones and voluntarily reduced or seasonally stopped fishing in the most important spawning and migration areas. This is leading to improved fish and game populations.[553]

The delta is also on the rise as a rewilding tourism destination; people visit from all over Europe and the nearby cities of Berlin and Szczecin to see wildlife, particularly the Oder Delta Big Seven: white-tailed eagle, European bison, beaver, elk, wolf, Atlantic sturgeon and grey seal. The tourism is spread out over the year with different seasonal wildlife spectacles. In the autumn and winter, guests travel to the smaller rivers and streams to see how salmon, sea trout and sturgeon return to their spawning grounds; track wolves; watch elk in the snow and white-tailed eagles gathering to hunt ducks around the mainly ice-covered lagoon; and view the grey seals' white-coated pups.[554]

Tourists have brought with them new economic opportunities for local people and enterprises. Hunting associations are guiding wildlife watching tours. Local people living around the lagoon have opened new B&Bs, small hotels and restaurants serving fish specialities from the delta and the Pomeranian Bay together with vegetables from the gardens and fields, berries and mushrooms from the forests, and meat from free ranging cattle and game. Oder nature is a source of pride for local people and most are willing to invest in rewilding interventions including the return of large mammals.[555]

Key challenges

Whilst local people are by and large supportive of rewilding, there is nevertheless some resistance to paying for the restoration of natural flooding regimes and the presence of large predator species.[556] As with many rewilding projects, human-wildlife conflict may cause issues in the future.

INDIGENOUS FIRE MANAGEMENT AND CARBON OFFSETTING, AUSTRALIA

Name	Warddeken Indigenous Protected Area
Designation type / protective mechanism	Category VI protected area
Designation status	Registered on the World Database on Protected Areas, 2009[557]
Primary aim/s	• Grassland carbon management and offsetting • Preservation of Indigenous culture and connection to land • Biodiversity protection • Water source protection
Area (ha)	1,394,951
Governance type	IPA

Management, restoration, protection mechanisms

The Indigenous-owned Warddeken Land Management Ltd (WLML) manages this IPA for the preservation of Indigenous culture, biodiversity, water table management, fire management and associated carbon offsetting. The IPA encompasses six outstation communities: Kabulwarnamyo, Manmoyi, Kamarrkawarn, Marlkawo, Kumarrirnbang and Kudjekbinj. Historically, in Australia traditional Indigenous fire management practices were suppressed. Without the regular burning, grassland fuel loads would build up, leading to frequent and intense bushfires burning uncontrolled over large areas. WLML restored traditional burning, and fire management is now conducted by Indigenous rangers using both traditional and contemporary practices. The reduction of high-fuel-load fires has avoided substantial carbon emissions, and generated revenue for the Nawarddeken people as a result of carbon offset sales.[558]

Biodiversity values

Warddeken IPA covers almost three-quarters of the West Arnhem Plateau bioregion, one of Australia's biodiversity hotspots. It is home to many endemic plants and threatened species (including the bustard, northern quoll, black wallaroo, Arnhem Land rock-rat and Oenpelli python) as well as the federally protected Arnhem Plateau Sandstone Shrubland Complex. The IPA also protects the headwaters of several major water catchments.[559]

Human and ecosystem service values

Between 2009 and 2015, WLML generated an income of around US$2.6 million from the sale of carbon offsets from traditional fire management to buyers including the IPA's corporate partner ConocoPhillips.[560]

Like much of rural Northern Territory, the Warddeken area suffers from high unemployment. Using the income raised from carbon credit sales and funds from the Indigenous Advancement Strategy, WLML provides jobs for Indigenous rangers to manage fire risks and invasive feral plants and animals, monitor threatened species, conserve rock art and cultural heritage and educate people on culture and biodiversity. In total the IPA employs up to 130 Indigenous rangers a year on casual and permanent contracts. In 2015, the IPA employed staff for a total of 4,208 days of employment. Between 2009 and 2015, 47% of the Indigenous staff were women and over this period US$2.3 million was paid in gross salaries.[561]

The Warddeken area also contains very important cultural and archaeological sites. Rock paintings tell creation stories, record the way Aboriginal people lived tens of thousands of years ago and even depict first contact with European settlers.[562] In protecting their environment and culture, IPA staff become role models in the community, passing on traditional ecological knowledge to younger generations and playing an important role in generating social cohesion and increasing collective esteem.[563]

Between 2009-2015, the social, economic, cultural and environmental benefits from protecting Warddeken were estimated at AU$55.4m. During this period, AU$16.6m was invested in the programmes, with most (62%) coming from government and carbon offset buyers (25%). That is, for every AU$1 invested, approximately AU$3.4 of social, economic, cultural and environmental value has been created for stakeholders.[564]

Key challenges

WLML has identified the biggest threat to the IPAs as rural depopulation of Indigenous peoples (or "Empty country") and subsequent loss of culture, language and land management knowledge and practices. Feral and invasive plants and animals are also a major concern. These include cane toads, cats and pigs, but also buffalo which present a unique problem: whilst buffalo threaten the ecosystem, they also provide a ready supply of fresh meat and are important to the IPA's food security.[565]

RESTORING BISON AND INDIGENOUS CULTURE IN THE NORTH AMERICAN PLAINS

Name	Bison restorations to Wanuskewin Heritage Park, the Key First Nation's grasslands and other First Nations territories
Designation type / protective mechanism	Parks Canada has supported or facilitated the transfer of bison to around 20 First Nations' territories
Designation status	N/A
Primary aim/s	Restoring bison, their ecological impacts and cultural connections Strengthening and preserving Indigenous culture and connection to land
Area (ha)	N/A
Governance type	Indigenous territory

Management, restoration, protection mechanisms

Bison are North America's largest land mammal and once tens of millions roamed across much of the continent. By the late 1800s, after years of European colonisation and industrial-scale overhunting, bison were near extinction. Around 1,000 wild plains bison remained, most in the Pablo-Allard herd owned by two Indigenous ranchers.[566] The Government of Canada bought 700 of their bison in the early 1900s and have been working since to maintain and restore bison herds, their health and genetics, for conservation.[567]

Bison herds have been restored to numerous state-owned protected areas and over 600 bison have been translocated to around 20 First Nations-managed sites to support them in establishing their own conservation or cultural herds. These sites include Wanuskewin Heritage Park and the Key First Nation's grasslands. These transfers help Indigenous peoples strengthen their cultural and historic connections with bison and develop social and economic opportunities around bison.[568]

Biodiversity values

Bison play a critical role in modifying grasslands through intense, irregular and ever-shifting herbivory.[569] Their impacts cause grasslands to green up faster, more vividly and for longer seasons and provide numerous habitats for other species.[570] For example, their dung incubates insect eggs and larvae eaten by many endangered prairie birds which also use their fur for nests. When bison take dust baths, they create "wallows" which fill with rainwater and provide important water sources for other prairie wildlife. Bison facilitate seed dispersal on their long coats as they travel through the landscape.[571]

Human and ecosystem service values

Across North America, the return of bison is increasing the uptake of grassland CO_2 through improving grassland health with nutrients in their dung.[572,573] Bison and their improved grassland ecosystems are also attracting tourists and boosting local nature-based economies.[574] However, in Indigenous-managed sites like Wanuskewin Heritage Park and the Key First Nation's grasslands it is the cultural benefits of the bison that are felt most keenly.

Bison have always been a cultural emblem for Indigenous peoples in the Prairie Provinces, connecting them to the land and their ways of knowing. The deep cultural and spiritual connections with the species include relying on the bison for food, shelter, clothing, tools, fuel, weapons, trade and social and ceremonial purposes.[575] Many Indigenous cultures view the bison as their relatives. The bison collapse created economic, spiritual and cultural losses for prairie Indigenous peoples, including The Key First Nation and restoring their bison has led to a cultural resurgence; bison are once again part of social and ceremonial events, youth have begun to better understand their connection with the species and their ancestors.[576]

Key challenges

Bison have undergone a significant genetic bottleneck in the recent past and so genetic resilience and resistance to pathogens like tuberculosis remains a concern. There are also no natural predators to keep the bison herds within the carrying capacity of some areas. Site managers must remove bison to prevent overpopulation and overgrazing. However, the removed animals also represent opportunities to transfer bison to other groups across North America.

NATIVE RESEEDING PROGRAMME IN THE GREAT PLAINS OF THE UNITED STATES

Name	WWF-US Great Plains Program, Native Grassland Reseeding Initiative
Designation type / protective mechanism	Partnerships with private ranchers, Tribes, and local landowner groups to restore native grasslands through voluntary reseeding agreements, cost-share programmes, and long-term conservation commitments
Designation status	N/A
Primary aim/s	Restore native prairie grasslands on previously cultivated or degraded lands Improve rangeland health, biodiversity and soil carbon storage Support sustainable ranching and rural livelihoods Enhance drought resilience and water infiltration Prevent grassland conversion through long-term conservation agreements
Area (ha)	Approximately 18,000 hectares (~45,000 acres) reseeded since 2018, with additional projects underway across the US states of South Dakota, Montana and Nebraska
Governance type	Privately owned and Tribally owned and managed lands; restoration projects led by individual ranchers or Tribal land managers with WWF technical and financial support

Management, restoration, protection mechanisms

Ranchers and land managers reseed former cropland or degraded rangeland with native prairie grasses and forbs, often following site preparation practices like weed control and soil amendments. Restored areas are often integrated into managed grazing systems (e.g., rest-rotation grazing) to ensure long-term grassland health. WWF provides cost-share funding, native seed, technical guidance, and, in certain cases, ecological monitoring support. Reseeded lands are protected under 10+ year no-conversion agreements.

Biodiversity values

- Recovery of native grassland plant species
- Improved habitat for grassland birds, pollinators and other prairie wildlife
- Enhanced ecosystem function, including soil health and water retention
- In the last four years, over 45,000 acres have been reseeded in the Northern Great Plains.

Human and ecosystem service values

- Increased drought resilience and forage availability for ranchers
- Improved economic viability of ranching operations through healthier rangelands
- Strengthened local conservation capacity and peer-to-peer learning among ranchers
- Contribution to carbon sequestration and climate mitigation goals

Key challenges

- Rising pressure from cropland expansion
- High costs of native seed and restoration implementation
- Climate variability, including drought and extreme weather, affecting reseeding success
- Ensuring long-term maintenance and grazing management of reseeded lands
- Need for expanded technical assistance and sustainable funding sources to scale up restoration across the vast Great Plains

RESTORING COMMUNITY GRASSLANDS IN CHYULU HILLS, KENYA

Name	Rangeland Restoration in Chyulu project, Kenya
Designation type / protective mechanism	Partnerships with local Maasai communities to restore native grasslands by integrating traditional ecological knowledge with scientific monitoring to underpin community-led management, improved grazing practices, and reseeding of native grasses
Designation status	Group Ranches
Primary aim/s	Restore degraded rangelands through reseeding and improved grazing Support pastoralist livelihoods via better forage and land productivity Enhance carbon storage and ecosystem resilience Strengthen community-led land management and governance
Area (ha)	The project aims to restore 20,000 hectares by 2027. Over 8,300 hectares were reseeded between 2018-2023,[577] following phases of community engagement, rangeland assessments, and planning. The reseeding targeted heavily degraded grazing areas using native drought-tolerant grasses to support ecosystem recovery and livestock productivity.
Governance type	Community-based governance and co-management

Management, restoration, protection mechanisms

The Chyulu Hills Rangeland Restoration Project focuses on restoring degraded grasslands through community-led management, improved grazing practices, and reseeding of native grasses. Led by the Satoyama Initiative and local Maasai communities, the project integrates traditional ecological knowledge with scientific monitoring to enhance biodiversity, carbon storage and pastoral livelihoods, contributing to climate resilience, water table protection and sustainable land use.[578]

Biodiversity values

- Reseeding of native grasses across more than 8,300 hectares
- Improved habitat for Kenya's largest population of African elephants and the critically-endangered black rhino
- Reduced invasive species, allowing native flora to re-establish
- Enhanced ecosystem connectivity across group ranches and neighbouring protected areas

Human and ecosystem service values

- Improved pastures for livestock, reducing encroachment onto protected areas and boosting pastoralist incomes
- Increased water retention, enhancing access to water for people
- Carbon sequestration, contributing to climate mitigation and potential carbon financing
- Strengthened community governance, empowering local stewardship of natural resources

Key challenges

- Invasive species and bush encroachment making it difficult to restore native grasses and maintain productive pastureland
- Overgrazing and limited enforcement of rotational grazing plans have led to continued degradation in some areas
- Climate variability and drought have slowed vegetation recovery, reduced seedling survival, and increased grazing pressure on restored areas, particularly in the dry seasons
- Community coordination and land tenure complexities
- Sustaining restoration financing

SAFEGUARDING OVERLOOKED ECOSYSTEMS IN SOUTH AMERICA

Name	Safeguarding Overlooked Ecosystems: Protect, Manage and Restore Grasslands and Savannahs in Argentina, Colombia and Paraguay[579]
Designation type / protective mechanism	Partnerships with private ranchers, local landowner groups, and Indigenous communities to protect, manage and restore native grasslands and savannahs in the Orinoquía, Pampas, Pantanal and Humid Chaco
Designation status	N/A
Primary aim/s	Support the creation and effective management of new and existing PCAs Enable updates to sustainable management models via awareness, capacity-building and knowledge exchange Pilot restoration methods for grassland and savannah ecosystems in Orinoquía, Pampas and Humid Chaco Share information and engage stakeholders on the role of grasslands and savannahs in national and global climate, restoration, and biodiversity goals Generate and share strong scientific evidence for the protection and sustainable use of grasslands and savannahs
Area (ha)	40,000 ha of new protected areas will be established, 34,000 ha of natural grasslands and savannahs will be brought into sustainable management, and 3,160 ha will be restored by 2029
Governance type	Privately owned and community-managed lands; restoration projects led by individual ranchers with WWF technical and financial support

Management, restoration, protection mechanisms

Grassland and savannah ecosystems in Argentina, Colombia and Paraguay share key socio-cultural, economic and environmental values. They host unique biodiversity, support water and food security, provide livelihoods, and preserve the cultural identity of rural and Indigenous communities. These ecosystems are threatened by climate and land use change, but protected areas and low-impact cattle ranching by local communities offer solutions. Through its "Protect, Manage, Restore" approach, the project promotes sustainable practices to build resilient, connected and productive landscapes, halting biodiversity loss and supporting climate mitigation and adaptation. It also raises global awareness and fosters community research and South-South knowledge exchange.

Biodiversity values

- Securing natural grasslands and savannahs from the threat of conversion to preserve plant diversity
- Improving habitat for grassland birds, pollinators and other wildlife
- Enhancing ecosystem function, including soil health and water retention

Human and ecosystem service values

- Increased forage availability and economic viability for ranchers through the adoption of sustainable management models
- Preserving local culture and ways of life connected to extensive cattle ranching
- Strengthened local conservation capacity and peer-to-peer learning
- Contribution to carbon sequestration and climate mitigation goals

Key challenges

- Rising pressure from infrastructure and agro-industrial expansion
- Lack of appreciation of grasslands and savannahs as strategic ecosystems in public policies
- Barriers to replication of successful pilots due to lack of resources, weak institutions or resistance to change in areas dominated by conventional livestock farming models

ALIANZA DEL PASTIZAL (GRASSLAND ALLIANCE)

Name	Alianza del Pastizal.[580]
Designation type / protective mechanism	Sustainable Management: Conservation and Production. KBAs and Focal Sites [581]
Designation status	N/A
Primary aim/s	To preserve natural grasslands and biodiversity in the Southern Cone of South America through coordinated actions among the four countries (Argentina, Brazil, Paraguay and Uruguay) and various sectors of society (producers, civil organisations, academia and governments), within the framework of harmonious and sustainable development of the region
Area (ha)	More than 1,330,000 ha
Governance type	Network of ca. 847 landowners, plus scientists, technicians, governments, NGOs, coordinated by BirdLife secretariat and its local partners, Aves Argentinas, Aves Uruguay, Guyra Paraguay and SAVE Brasil.

Management, restoration, protection mechanisms

BirdLife and its partners have already made significant strides in identifying and conserving critical habitats for grassland species. This has included the identification of numerous Key Biodiversity Areas (KBAs) across the region, which have become focal points for conservation action.[582] The Alianza del Pastizal has successfully integrated sustainable livestock production with biodiversity conservation, demonstrating that these goals are not mutually exclusive. The collaborative efforts of BirdLife and its partners have resulted in the preservation of large areas of native grasslands (1.33 million hectares currently), helping to safeguard critical habitats for migratory grassland birds and other wildlife. Within these efforts we developed a Conservation Investment Strategy for improving habitat quality and connectivity for migratory and resident neotropical grassland birds in the Southern Cone Grasslands of South America (SCG-CIS).[583]

The vision of the Grassland Alliance is for a region of grasslands where:

- Cattle ranching in Natural Grasslands becomes a more competitive and profitable activity, developed sustainably by favouring the conservation of grasslands under grazing systems suitable for ecosystem preservation.
- Agriculture and afforestation are carried out responsibly, with careful soil and water treatment, prudent management of agrochemicals, and allowing sufficient areas for native wildlife in grasslands.
- Urban growth considers the Pampas landscape, ensuring the conservation of natural grasslands.
- Officially recognised protected areas preserve at least 10% of the original natural grasslands in each country and are properly implemented for effective fulfilment of their function.
- The traditional culture of the Pampas holds a relevant place in our societies.

This strategy is being replicated by other BirdLife partners in the Americas: in the Colombian Llanos with the “Savannah Alliance” (Calidris) and the “Alianza Eco-Ganadera Beni” in the Bolivian Llanos (Armonía).

Biodiversity values

The Pampas grasslands are located in the Southern Cone of South America, representing one of the most extensive and biodiverse grassland areas globally,[584,585] providing ecosystem services that support millions of people. Although currently being updated, 96 Important Bird Areas (IBAs) or Key Biodiversity Areas (KBAs) have been identified in the region.[586,587]

This region consists of lowland grasslands dominated by grasses and other herbaceous species, covering more than 100 million hectares,[588] distributed across Argentina (60%), Uruguay (20%), Brazil (18%) and Paraguay (2%).

The grasslands within the focus of this plan harbour a unique diversity of wildlife and flora, including 540 resident and migratory bird species, 138 mammals, 225 reptiles and thousands of plant species**,** with more than 550 grasses – approximately 130 species classified under some level of threat. More than one-fifth of the recorded bird species are globally threatened to some extent.[589]

Human and ecosystem service values

The Pampas grasslands provide a wide range of essential ecosystem services. In addition to their rich biodiversity, scenic beauty, recreational value, and role in air purification, these grasslands support millions of people by providing crucial resources and ecological benefits, including:[590]

1. Food production: In 2012, the region supported 8% of all cattle and 17% of all sheep in the Americas using only 1.6% of the land and contributed 3.4% of globally exported boneless meat from just 0.3% of the global land area.
1. Carbon storage: Despite covering less than 3% of Latin America, these grasslands hold 5% of the region's total soil carbon stock. Soil organic carbon (SOC) content varies across subregions, with declines observed when native grasslands are converted to crops (e.g., 30% SOC loss after 30 years in some areas).
1. Climate change mitigation: Research has quantified greenhouse gas emissions from livestock grazing different forage types. Native grasslands generally have lower methane emissions per unit of weight gain than intensively managed systems.
1. Water regulation: Healthy grasslands use water more efficiently contributing to improving water retention and reducing water erosion, preventing flooding, etc. Land use changes, such as afforestation and crop expansion, alter regional hydrology, reducing water availability in certain areas.
1. Nutrient cycling: Grazing has mixed effects on soil nitrogen and phosphorus levels, with some studies indicating increased nutrient availability and others showing depletion.
1. Erosion control: Native grasslands have lower erosion rates than croplands. Overgrazed areas experience moderate erosion, while continuous cropping results in the highest rates (up to 67 Mg ha^{-1} yr^{-1}). Well-managed native grasslands maintain significantly lower soil loss.
1. Cultural value: These ecosystems represent a significant cultural heritage. There is a strong cultural identity linked to cattle-breeding, usually identified with the "gaucho" tradition.[591,592]

Key challenges

Some of the main challenges include:

- Lack and complexity of financing and incentives for sustainable production
- Need for government support (pending laws and projects)
- Complexity of differential markets
- Coordination with other NGOs and academic institutions
- Consumers not valuing or being unaware of environmentally friendly products
- Misconceptions about biodiversity, regeneration and sustainability
- Changing mindsets to transition from unsustainable management to more sustainable practices
- Undervaluing or lack of recognition of the importance of grasslands by public and private sectors, general public, etc.
- Market incentives promote rapid land conversion to monocropping, mainly soybean
- Perverse incentives that promote afforestation with exotic species, such as for carbon projects, leading to biodiversity loss and ecosystem degradation
- Grasslands being seen as sacrifice environments rather than ecosystems of high conservation value
- Lack of positioning in local, regional and global conservation agendas

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