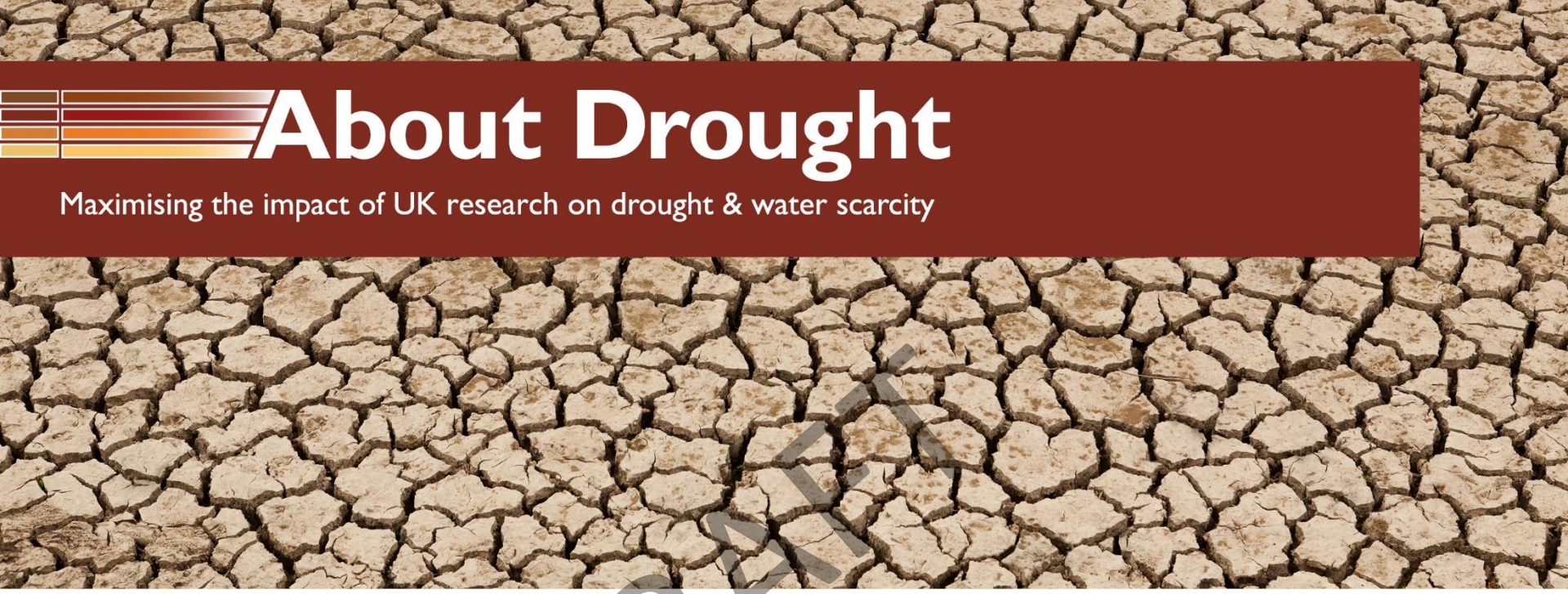


About Drought

Maximising the impact of UK research on drought & water scarcity

Grasslands and Drought

Report Card 2019

This publication covers the impacts of drought and water scarcity on grasslands, particularly those in the UK. We cover the ecosystem responses, future scenarios and potential for drought management
It has been produced by About Drought, the UK's Drought & Water Scarcity Research Programme, which consists of 5 integrated research projects, funded by the UK research councils.

This is one of a series of report cards that summarise current and future aspects of water scarcity in the main UK ecosystems.

Prepared by: Jill Thompson (CEH), Sarah Ayling (UWE)

Historic Droughts

MaRIUS
Managing the risks, impacts and uncertainties of droughts and water scarcity

IMPETUS
IMPROVING PREDICTIONS OF UK DROUGHT

Drought Risk and You

Drought in UK

Droughts and water scarcity are becoming more common in the UK, as a result of climate change and increasing human water use.

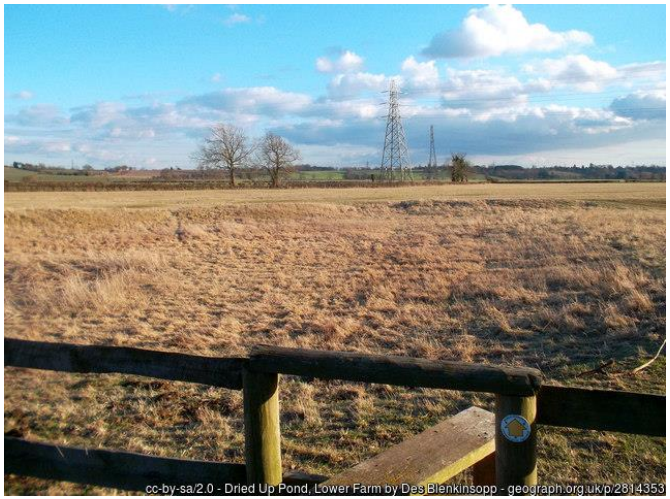
We generally think of a "drought", as an attribute of the environment and local weather. The effect of different weather patterns on the land, plants and animals and the probability of drought depends upon how much water plants and animals use, and the rate of evaporation. High atmospheric temperatures and sunlight intensity impact water use and are often associated with drought. It is often difficult to define when a drought starts, as this depends upon the environmental system that is being affected. Droughts generally develop gradually as the time since the last precipitation (rainfall, fog and snow) increases, and if water use is greater than precipitation. A drought might take a long time to be seen in a grassland, as the plants use up available soil water, growth slows, then plants may shrivel and die. A river might be more quickly affected if the flow of water slows to a trickle that is too low to sustain the rivers animal and plant life.

Water scarcity is often associated with environmental drought combined with water consumption. When water provision by local weather is low and atmospheric temperatures are high, if the rate of abstraction of water from aquifers, rivers, lakes and reservoirs is greater than the rate that water is replenished, then water scarcity occurs. People contribute to water scarcity by reducing amount of water entering soil and aquifers, and increasing the rate of water loss in runoff. They also cause water pollution and increase the need for costly water treatment, which slows the rate of delivery of clean water for human use. These impacts on our water resource have direct consequences for human health, and also affect many habitats and wildlife, farming and livestock.

Predicted climate change in UK, which includes rising temperature, and changes in precipitation amount and annual distribution, is increasing the likelihood that people and the environment will suffer from water scarcity and drought. The impact of climate change depends upon where you are in the country and the needs of people and habitat for water.

Each drought event, its effect on the environment, individual habitats and at each location is unique, but there are many things we can do to reduce the effect of water scarcity and drought: these will be considered in the following pages.

Drought is considered an attribute of environment and climate, rather than failure to deliver water for other man made reasons.



Grasslands in the UK, and their importance

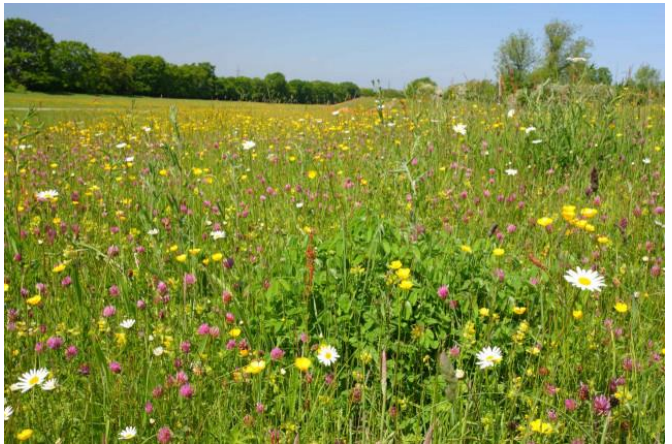
There are many different types of grassland in the UK. The classifications most commonly used are natural, semi natural and managed grasslands and are based upon the abundance of grasses, other species present, and abiotic and climatic conditions at the location. The Joint Nature Conservation Committee (JNCC), and the National Vegetation Classification (NVC) are the most well known in the UK. The JNCC recognize six grassland types, Lowland calcareous, Lowland dry acid, Lowland meadows, Upland hay meadows, Purple moor grass and rush pasture, and Calaminarian grasslands that are found on soils with high levels of heavy metals (eg lead, zinc chromium and copper), which are toxic to most plant species. The NVC (Rodwell 1992 vol 3) describes three main types of grasslands; Mesotrophic, Calcicolous, and Calcifugous and montane communities, but we may also instinctively describe many heath communities (NVC vol 2) as grasslands. The NVC grassland types can be subdivided into many subcommunities that have a wide range of species numbers and type of species. Mesotropic grasslands have between 45-105, calcicolous 85-153, calcifugous and montane 36-172, and heathland 38-95 species (Rodwell 1992 NVC). Species have different functional traits and individual tolerances to drought, and grow in different environmental conditions, therefore, it is difficult to quantify grassland community resistance and resilience to drought. As a result it is also difficult to predict the impact of drought on the wide range of grassland communities.

Estimates of grassland area and their economic importance depend upon the definition of grassland, e.g. whether natural and semi natural, forage, recreational or grass crops, and the methods used to calculate it. The World Resource Institute estimated 31-43% of the Earth's habitats are grassland. The Wildlife Trusts estimated 40% of UK is grassland, with most of it as farmland or upland grazing, with only a small amount that is unimproved. Many grassland types are under threat with some having conservation priority status. In the UK there are only around 200 species rich floodplain meadows remaining, with 97% of lowland meadows and pastures lost since 1935 through changes in farming.

In addition to natural and semi natural grasslands there are those that are specifically planted, frequently with a single or few species. These include grasslands for recreation in gardens and sports grounds, agricultural grasslands such as wheat and barley crops, or pastures for animals. In 2009 agricultural grasslands, including permanent and temporary rough grazing covered 70% of UK land.

Grasslands with their mixture of non grass species provide a range of important ecological functions and ecosystem services for humans, such as removing carbon dioxide from the atmosphere, carbon storage, water filtration, prevention of soil erosion, pollinator services, wildlife habitat, grazing for farmed animals and cultural and aesthetic value eg flower filled meadows, and

Grasslands are the most common UK land cover and provide many ecosystem services. Their responses to drought depend upon the species present, and the environment conditions.

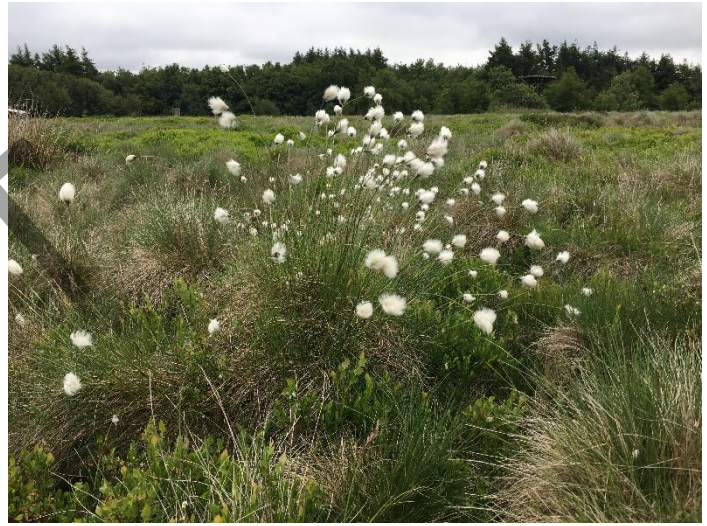


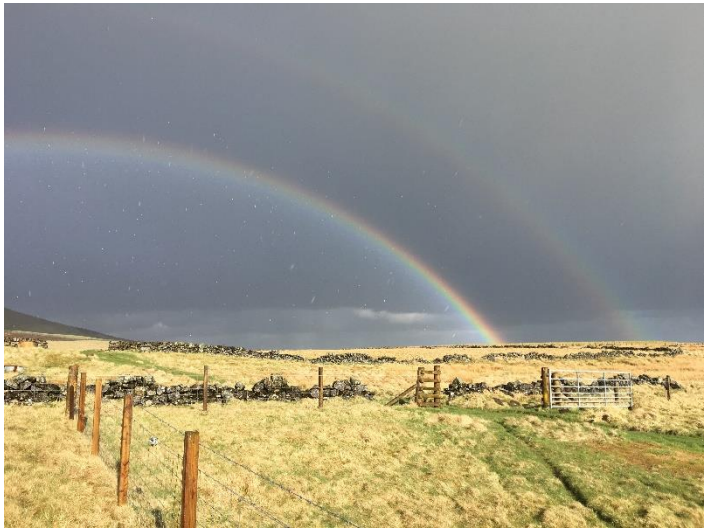
With permission Mesotropic grassland hay meadow. Rawcliffe Meadows 2013 (c) Whitfield Benson. https://rawcliffemeadows.wordpress.com/

Impact of drought on UK grasslands

The historical climatic regime and current climate, soil type and hydrological conditions, the impact of wildlife and livestock, historical and current land use, and management regime all contribute to explaining the different species communities and vegetation structure of grasslands. Grassland response to drought is depends upon all of these factors that determine the type and location of the grassland, the climatic conditions that influence the rate of development and progression of drought conditions, and the complex interplay between biotic and abiotic factors. The impact of drought on grasslands could be short or long term depending upon the species present, their individual species characteristics and grassland type prior to the drought. Species differ in responses at different life stages eg fruit production, establishment, growth and survival and the mechanisms they use could involve physiological, structural and growth adaptations. Many grasslands are well adapted to seasonal variations in water supply, and short term water shortage, and are able to recover rapidly once water availability improves. Grasslands that are adapted to flooding, may be more sensitive to drought than those that are found on sandy soil with more drought resistant species. Drought has feedback effects on soil nutrient status, such as soil plant available nitrogen through microbial processes that are sensitive to water shortage.

The site conditions and rate of drought development makes each location unique. The impact of drought in any location is as complex as the conditions that determine the grassland type. Where drought is severe, and if many of the original species are lost, the drought impact may create a dramatic environmental transformation that is impossible to reverse. Little information is available on the relative drought resistance of UK grassland species. More research is required to assess the impact of future droughts on natural and farmed grassland communities





There are many different types of grassland in a wide range of locations and environmental conditions. Predicting the response of grassland to drought requires much research.

Photo © Jill Thompson - top High Bradfield, lower Craigmeads meadow

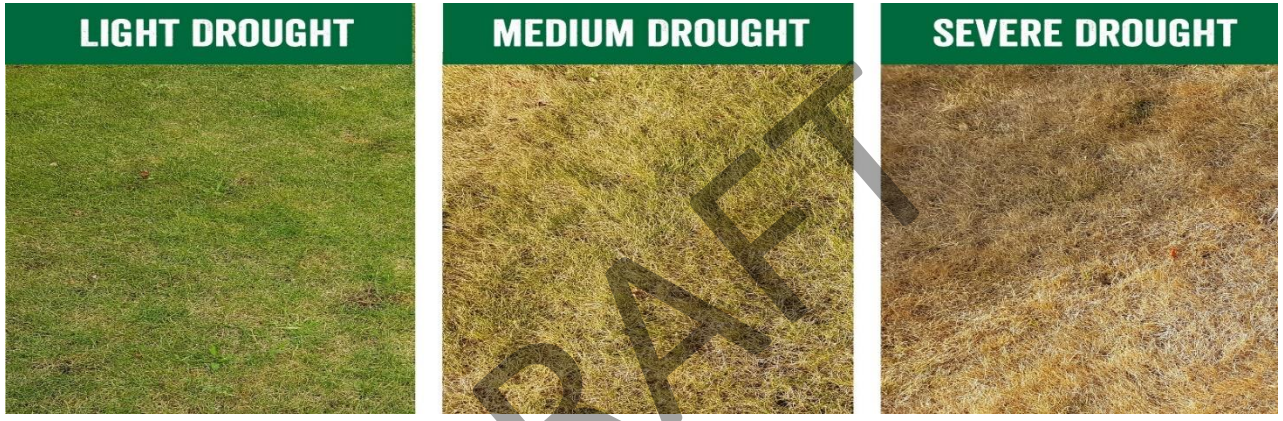
Background 4

Drought likelihood and severity – effects on grassland

	Severity of damage to grasslands as climate changes		
	Mild	Moderate	Severe
Likelihood*			
Low	If climate predictions are correct then there is a low probability of only mild droughts that cause light damage to grasslands. If these occur then grasslands will likely be able to recover without much change.	Moderate severity has a low likelihood of occurring depending upon the climate scenarios considered. A moderate drought occurring occasionally may result in some species change and biomass reduction, but recovery is likely.	There is a low likelihood of very severe drought over large parts of the UK, but if these did occur there will be great economic losses and much damage to grassland ecosystems
Medium	A mild drought occurring only occasionally in non-consecutive years may result in some biomass reduction, but recovery is likely when rainfall returns.	A moderate intensity drought occurring in some years, and in consecutive years will likely lead to biomass reduction and change in species composition that may take time to recover. Invasive drought resistant species may change the sward characteristics. Recovery may be slow if seed source of native species is low.	Severe drought occurring at medium likelihood will increase potential for loss of biomass, and agricultural crops, if not managed well. Depending upon extent of area under drought, recovery without human intervention may be slow.
High	This condition may occur in some parts of the UK that are already suffering from drought. Drought might increase in frequency in consecutive years. Change in abundance of some species that are not able to adapt to drought, and that may die may not easily be replaced if a seed source not available.	Loss of less drought tolerant or adaptable species, increase abundance of remaining species or invasion by new species. Loss of biomass and slow recovery.	High likelihood of severe drought may also have large spatial extent. Likelihood of fire increases and significant change or loss of ecosystem function that will not easily recover.

Stages of drought in a garden lawn

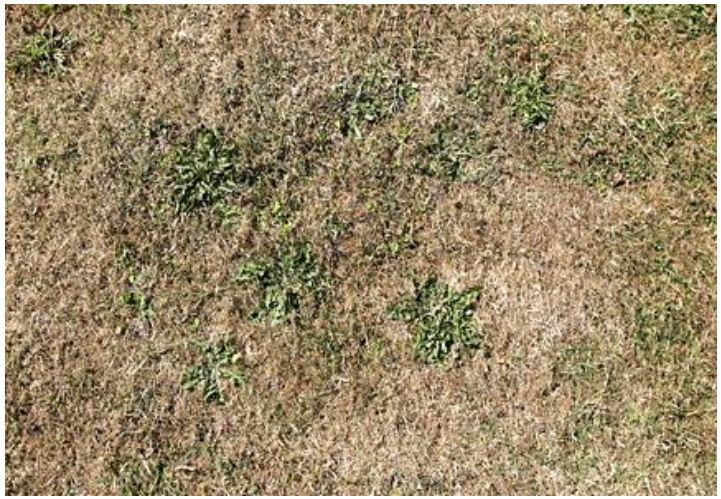
The effect of drought on garden lawns …



© - https://www.gardenhealth.com/advice/lawns-articles/how-to-recover-your-lawn-after-a-drought

The development of drought is often slow and depends upon the species composition, environmental characteristics, such as soil type, and length of time since last rainfall. Many grasses die back above the ground but rapidly grow new shoots when the rain returns.

Some species are more resistant to drought than grasses as they have deeper roots. Drought damage may allow other species to invade.



Royal Horticultural Society picture © Neil Hepworth
https://www.rhs.org.uk/advice/profile?pid=417

Physical effect of drought

Physical effects of drought & management actions

Effects	Grassland response	Future scenarios	Management for all effects
1) Slower plant growth and drying of plant material may reduce palatability for wild herbivores and farmed animals. Longterm drought may cause plant death.	Depending on time of drought; death of plants, change in species community composition and vegetation structure, lower biomass and grain production. Drought at the right time may result in high quality hay and grain crops.	Short term droughts with adequate precipitation allows regrowth of plants from underground roots or soil seed bank. Long term drought with inadequate water results in loss of grassland habitat, and may need changes in farming practises.	**M1** Irrigate pasture and crops. Irrigation possibly not economic especially for pasture, nor practical for natural and semi-natural ecosystems. Reduce farmed animal populations, or feed animals processed and imported food. **M2** Establish terraces and landscape features to reduce water loss and soil erosion. Reduce soil tilling. Protect water bodies from eroded soil and pollution. Store water in reservoirs, Reduce the water loss from streams and rivers, and maintain ground water. **M3** Remove build up of dead grassland biomass and take actions to prevent fires.
2) Depending upon soil type. Clay soil drying may cause soil to become hard, shrinkage causes root damage and dry cracked soil results in water runoff on rewetting.	Damage to plant roots may case plant death. Roots unable to penetrate soil. Soil organisms unable to move through soil.	Short time before return of rainfall allows recovery of soil structure and soil cracks will close. Long time under drought conditions causes plant and soil organism death.	
3) Depending upon soil type. Sandy, loam and peat soil- drought may damage soil structure.	Plants may die and soil may suffer increased erosion from wind and water (when precipitation returns)	Loss of top soil will reduce potential for recolonization by grassland community.	

Physical effect depends upon soil type and species composition. Clay soil becomes hard, loam soil might suffer increased erosion when precipitation returns.

Cracked earth- © Sarah Ayling

Management Actions - Chemical

Chemical effects of drought & management actions

Effects	Response	Future scenarios	Management for all effects
1)Droughts may reduce the availability of plant nutrients from the soil as these require water for plant uptake	Nutrient limitation will reduce plant growth and nutrient composition of plant material. Plant physiology will change.	Some species might be lost from the community for the short term or permanently.	**M1** Irrigate pasture and crops. Irrigation possibly not economic especially for pasture, nor practical for natural and semi-natural ecosystems. Long term reduce farmed animal populations or feed processed and imported food. Provide artificial water sources. **M2** Establish terraces and landscape features to reduce water loss (during precipitation events) and soil erosion, protect water bodies from eroded soil and pollution. Store water in reservoirs, Reduce the water loss from streams and rivers. Maintain ground water aquafers. **M3** Remove build up of dead biomass and take actions to prevent fires. **M4** Not useful to replace nutrients without also adding water to allow nutrient uptake.
2)Decomposition rate will be reduced, which will limit the return of nutrients to the soil for subsequent plant uptake.	Build up of undecomposed material will increase and change soil nutrient status and carbon content.	Potential for increased risk and intensity of fire in undecomposed plant material. Flush of nutrients on rewetting.	
3)Drought induced change in species and biological activity will affect soil nutrients and chemical composition.	Depending upon soil type and initial status soil nutrient status and carbon content may change.	Changes in soil health and quality for plant growth and soil organisms.	
4)Change in production of greenhouse gasses. These may increase or decrease depending upon action of soil organisms and soil redox state.	Greenhouse gas production will likely decrease during drought, but increase rapidly when drought is over.	Greenhouse gas production may affect global warming.	
5)Change in soil pH, oxygen content and redox potential.	Change in nutrient availability and toxicity of some elements present in soil. Change in biochemical status such as redox potential will affect plant growth.	Depending upon grassland species and individual responses some species may be replaced and biomass reduced.	

Management Actions – Biological 1

Biological effects of drought & management actions

Effects	Response	Future scenarios	Management for all effects
1) Depending upon when drought occurs may change growth and reproduction patterns eg change growth and flowering phenology, reduce vegetative and seed production, prevent seed germination. Affects all grassland types natural, semi natural, recreational and farmed	Gradual deterioration of grassland community as species are lost depending upon the sensitivity and adaptability of the initial plant species and their community.	Length of drought and intensity increases. Will change species composition of grasslands as species that can not adapt die. Species that are not characteristic invade. Some species might adapt to drought conditions, if they develop over sufficient time.	**M1** Grow drought tolerant varieties of preferred crops or change the crops in these areas. **M2** Sow different grasses and other species for forage or recreation areas. Use species with range of drought adaptation mechanisms such as with rolled leaves (*Festuca sp.*) or deep roots (*F. arundinacea, Cynodon dactylon*) or capacity to regrow quickly after drought dieback. **M3** Actively re-establish semi-natural grassland community by direct planting and sowing seed. **M4** Install irrigation systems and water storage facilities. **M5** Manage soil conditions to reduce soil erosion, increase water holding capacity of soil, replace nutrients, increase rate of infiltration of water into soil and depth that roots can reach. **M6** Mechanically remove build up of dead grassland and take actions to reduce fire risk. **M7** May not be possible, or desirable, to re-create the original grassland community. **See further management actions next slide.**
2) Directly kill all plants or aboveground parts – depending upon length and intensity of drought.	Loss of species from community or death of whole community. Depends upon initial type of grassland community.	Loss of grasslands habitat for wildlife, forage for farmed animals and crops. Increased fire risk from accumulated dried plant material.	
3) Change in species composition. Affects all grassland types natural, semi natural, recreational, and farmed and managed pastures.	Gradual change in species of grassland community as drought intolerant species are lost (depending upon the sensitivity and adaptability of the initial plant species and their community). Invasion or increased abundance more drought tolerant species.	Length of drought and intensity increases. Will change species composition of grasslands as species that can not adapt die, and others increase abundance eg *Rumex obtusifolius*. Some species might adapt to drought conditions, if these develop over sufficient time. Species that are not characteristic invade grasslands, such as shrubs and tree with deeper roots and better access to water	

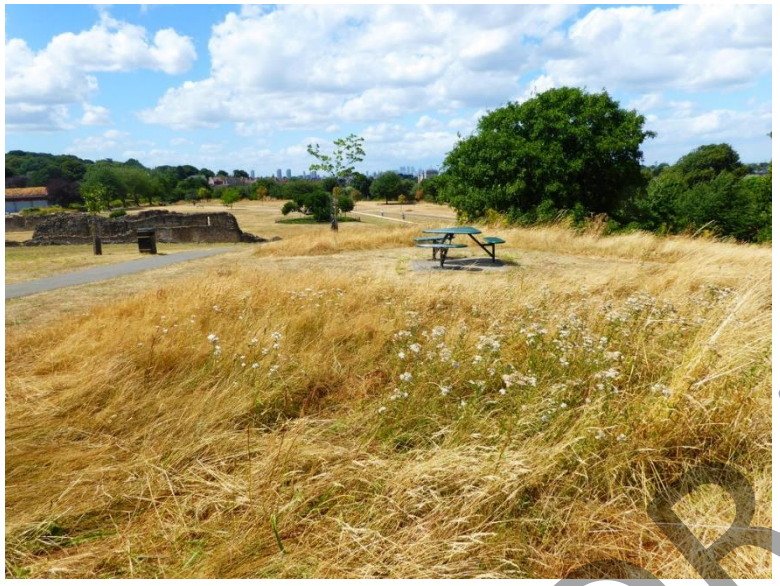
Management Actions – Biological 2

Biological effects of drought & management actions

Effects	Response	Future scenarios	Management for all effects
4) Change in grassland structure. Affects all grassland types natural, semi natural, recreational and farmed	Loss of species from community or death of whole community. Depends upon initial type of grassland community. Reduction in biomass for hay and silage.	Loss of grasslands habitat for wildlife, forage for farmed animals and crops. Increased fire risk from accumulated dried plant material.	**See Management methods 1-7 previous slide.** **M8** Grow different crops, tolerant varieties For example Quinoa (*Chenopodium quinoa),* which tolerates a wide variety of climatic conditions. **M9** Change the management regime to reduce drought impact. such as time of sowing, sowing density, fertilizer application and time of harvesting. **M10** Use pesticides to manage pests and diseases, and herbicides to remove unwanted plant species. **M11** Apply anti-transpirants to crops, to reduce water loss.
5) Slow decomposition rate by reducing the activity or killing fungi, bacteria and other soil organisms. Build up of undecomposed plant material. Kill or reduce abundance of grassland dependent animals and insects.	Loss of soil function and nutrients. Change in community of soil organisms and ecosystem.	Potential for fires to develop on dry grasslands with accumulation of flammable material. Fire may then change species composition or depending upon intensity and fire temperature, kill plants and soil organisms and destroy grassland. New animals and insects may occupy changed habitat.	
6) Crop seed production reduced.	Loss of crops such as wheat and barley, as a result of no or low seed production.	May not be able to use some locations for crop production or not able to crow usual type of crop in a particular location.	
7) Grassland plants and crops more susceptible to pests and disease.	Increase in pests and diseases on crops reduces productivity. Loss of grassland species from pastures or natural grassland sites	May not be able to used some usual location for particular crops.	

Biological effects 2- photographs

Biological effects of drought.



Build up of biomass and fire hazard. Photo © Marathon (cc-by-sa/2.0)

Different species, different drought susceptibility
Photo © Patrick Roger (cc-by-sa/2.0)

Crop damage and soil cracking. Photo © Kate Jewell (cc-by-sa/2.0)
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Photo: Emma Shepherd

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