Heathland, Scrub and Savanna: Overview, Recent Trends and Outlook

Nadja El Balti

Abstract This contribution provides an overview of the ecology and distribution of the various habitat types which are dominated by small and intermediate-sized woody plants.

Compared to other ecosystem types such as forest or freshwater ecosystems, heaths and scrub have only fairly recently become a central theme of ecological and biogeographical research, and have only been the subject of comparatively few studies to date. Furthermore, these habitats cover only a small proportion of land compared, for example, with forest and grassland. In contrast to the amount of research, and despite the small area of land they cover, these habitats are rich in species and endemics.

Heathland, scrub and savanna comprise a variety of different habitat types and are found from polar regions to the tropics, and from oceanic to continental zones. In general, they occur as transition zones between open landscapes and forest or form a late succession stage in regions with environmental conditions that are unfavourable for tree growth.

Heathlands, especially in Europe, are often the result of long-term anthropogenic influence. Savannas can be found in subtropical and tropical regions and are characterised by a combination of tree and herbaceous species. Both heathlands and savanna provide habitat for many rare, threatened and endemic animals.

The degree of degradation and fragmentation of these habitats varies considerably. Urbanisation, the intensification of agriculture and exploitation for natural resources are the main threats to heath, scrub and savanna worldwide. As the usage of European heathlands for anthropogenic purposes decreases, succession results, thus leading to a reduction in the total area covered by this habitat type.

It is difficult to predict what these very dynamic ecosystems will look like in the future. However, the relatively high number of different habitat types, structures, and species highlights the importance of conservation planning and management of these habitats.

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It generally takes less time to re-establish dwarf shrub or shrub communities than it does for a forest to grow old. This fact can also be seen as an opportunity, especially if rare or threatened species can live in both shrubland and forest.

Keywords Heathland · Savanna · Shrubland · Threats to biodiversity · Future perspectives

1 Introduction: Classification and Terminology

Heathland and shrub habitats include all ecosystems dominated by shrubs and small trees (Davies et al. 2004; Specht 1979a). The maximum height of the vegetation is usually defined as 5 m. The vegetation carpet is open, and many grasses, herbs and mosses can be found. In many regions, such habitats are influenced to a greater or lesser degree by anthropogenic activity. Heathlands and shrubs are often successional stages and can develop e.g. from forests and woodlands or grassland (Hobohm 2014). Under environmental conditions which are not favourable for the growth of trees this habitat type can also occur naturally and remain for long periods of time in the same place.

Heathlands are characterized by short perennial ericoid plants on nutrient-poor soils (Specht 1979a, b).

The term *scrub* comprises different ecosystem types, all of which are characterised by the presence of small, woody perennial plants (Weber 2008). A number of terms such as savanna, heathland, shrubland or others are used in different parts of the world to describe these types of ecosystems; many of these terms are not explicitly distinct from one another and can be used for the same entity. Table 1 gives some definitions or descriptions as used in the literature.

Compared to other habitat types such as forest or freshwater ecosystems, heath and scrub have only fairly recently become a central theme of ecological and biogeographical research, and have only been the subject of comparatively few studies to date. Furthermore, the area covered by these habitats is only small compared to that covered by forest and grassland. Although not well studied, and despite the small area they cover, these habitats are very rich in species and endemics.

The structure of savanna ecosystems is characterised by a combination of single trees or groups of woody plants together with more open land dominated by grasses and herbs. Such ecosystems are found in particular in tropical and subtropical zones. Savannas occupy one fifth of the global land surface (Sankaran et al. 2010). Africa has the most well known savanna, but savannas also exist in South America, Southeast Asia and Australia (Pfadenhauer and Klötzli 2013), and often represent a transition zone between woodland and grassland. One common characteristic of savannas under the otherwise different climatic conditions is the seasonal rainfall (Solbrig et al. 1996). The term *savanna* originates from a native American language (Marchant 2010) and designates a landscape that can harbour a variety of

Table 1 Terms used for woody vegetation units of small and intermediate height

Habitat	Definition	References
Heath	Evergreen ericaceous dwarf shrub vegetation on nutrient- poor soil, for example in temperate regions of Europe. Mediterranean heaths are often dominated by larger shrubs such as *Cistus* spp.	Specht (1979a, b), Janssen et al. (2016)
Scrub	Vegetation type dominated by woody shrubs, often of varying height and structure	Weber (2008)
Shrubland	Vegetation dominated by woody shrubs mixed with grasses and herbaceous plants on different soils	Weber (2008)
Savanna	A combination of a discontinuous tree layer and a continuous layer dominated by grasses and/or herbs. This term is rarely used in Europe even if related vegetation units exist (e.g. dehesa)	Foxcroft and Richardson (2010), Joffre et al. (1999)
Chaparral	Evergreen shrub formation of SW North America	Hanes (1981)
Garrigue	Evergreen sclerophyllous low shrubs of the Mediterranean area forming an open canopy structure	Davies et al. (2004)
Macchia	Evergreen sclerophyllous shrubs of the Mediterranean area forming a closed canopy structure	Davies et al. (2004)
Mallee	"Is a colloquial name that is used to describe species of *Eucalyptus* that have a low shrubby growth form"	Menkhorst and Bennett (1989, p 39)
Kwongan	Sclerophyllous shrub vegetation of Australia	Rea et al. (2011)
Matorral	Sclerophyllous shrub vegetation of Chile	Fuentes et al. (1986)
Cerrado	Biome in S America including various types of grassland, savanna and woodland	Ratter et al. (1997)
Fynbos	Heathland of South Africa	Kruger (1979)

ecosystems. Grazing by wild and domestic animals, fire, and in some regions the direct influence of man form the landscape of the savanna and in some cases limit succession to woodland.

For a long time, transition zones in space and intermediate succession stages, especially shrub and fringe habitats, were disregarded in science. Today, however, the value of these habitats is more widely appreciated. Scrub and heaths are recognized as distinct and ecologically specialised ecosystems, often representing a transition zone or succession stage, which thus play an important role in the networking of different ecosystems (Rego et al. 2013). The habitat degradation and loss which have occurred in the last decade highlight the importance of protecting and restoring these habitats (Fagundez 2013).

Scrubs and heaths can be found all over the world, from polar regions to tropical regions (Specht 1979a, b); they often occupy only small areas and show great diversity from one region to another.

2 Heathland, Shrub and Savanna Habitats Around the World

Around the world, each region harbors a great variety of shrub, heathland and/or savanna habitats with a unique and characteristic species composition. The following examples provide an overview of the variety of these habitats, their ecological conditions and threats. They are intended to highlight the importance of protecting and managing these ecosystems.

2.1 Europe

Across Europe, most heathlands and shrub habitats are manmade and influenced by activities, such as grazing, fire, and felling of trees for timber, that open up the landscape (Gimingham et al. 1979).

The first occurrence of inland heath dates back to c. 4000 years BP (Webb 1998). Climatic conditions which limit the growth of trees favour the development of heathland (Heil and Aert 1993). This is often the case in alpine zones (Fig. 1), in coastal regions and in the tundra of the arctic region.

Heaths and shrublands are widespread today and can be found from the Arctic to the Mediterranean, and from coastal to eastern continental regions.

Fig. 1 Shrub vegetation in alpine zones of the Austrian Alps (photographed by author)

Table 2 Endangered heath and shrubland habitats of Europe (Janssen et al. 2016; *VU* vulnerable, *EN* endangered)

Code	Habitat type	Red List category EU 28+
F3.1d	Balkan-Anatolian submontane genistoid scrub	VU
F4.1	Wet heath	VU
F4.2	Dry heath	VU
F5.5	Thermomediterranean scrub	VU
F8.1	Canarian xerophytic scrub	VU
F8.2	Madeiran xerophytic scrub	EN

Fig. 2 Dry heathland dominated by *Calluna vulgaris* in N Germany (photographed by the author)

The European Red List of Habitats describes 40 different habitat types of heathlands and shrubs. It also classifies the degree of endangerment of the different terrestrial and marine habitats and gives an overview of the distribution and endangerment of each habitat type. The heathland and shrub habitats of the Mediterranean, Macaronesaian and Atlantic Regions are very diverse, with 13% of the described habitats classified as vulnerable. These occur in different regions of Europe (Table 2) (Janssen et al. 2016).

An example of a vulnerable habitat is dry heath (F4.2) (Fig. 2), one of the most important and widespread heathland habitats in Western Europe with a current estimated total area of 25,822 km^2 (Janssen et al. 2016), a high proportion of

which is of anthropogenic origin. This habitat hosts a great diversity of invertebrates, including numerous species of insects (Webb and Hopkins 1984; Schirmel et al. 2010).

The Madeiran xerophytic scrub (F8.2) is classified as endangered. Succulent plant species, many of them endemic, form this habitat. The current estimated total area of this scrub habitat is only 2 km^2 (Janssen et al. 2016).

The subalpine *Pinus mugo* scrub F2.4 is an example of a natural transitional shrub habitat type. This shrub type can be found in the mountains of central and south-eastern Europe (Janssen et al. 2016). Above the timberline, *Pinus mugo* forms dwarf shrubs (Sibik et al. 2010), which mark the transition zone between the forest and the alpine vegetation (Zeidler et al. 2012).

Another habitat type, the shrub tundra F1.1, occurs under extreme environmental conditions, where cold climate conditions do not allow the growth of trees (Bliss 1979). The shrub tundra is a transition zone between the taiga and the grassland tundra. In Europe, this habitat type can be found in Spitzbergen (Norway), Russia, Iceland and north continental Scandinavia (Davies et al. 2004). This type of shrub harbours many mosses and lichens.

The Macaronesian F4.3 heathlands are unique in terms of species composition. They harbour many threatened and/or endemic plant species (Page 1976).

A variety of ecosystems that belong to heaths and scrub can be found in the Mediterranean regions. Some of these are natural vegetation units but many of them are the result of anthropogenic use and activities where fire, grazing and deforestation have transformed woodlands into a more open landscape with shrubs and grasses. In some regions, these ecosystems are called maquis or macchia. When anthropogenic impact is more intense, they may develop into garrigue with dwarf and spiny shrubs, many annuals and vernal geophytes (Davies et al. 2004). The maquis and garrigue are part of the Mediterranean biome. The Mediterranean shrublands are species-rich (Walter and Breckle 1991) and they harbour many endemic plant species (Hobohm 2014).

Heathland and shrubland in Europe harbour more endemic vascular plants than e.g. woodlands, freshwater habitats or mires (Bruchmann and Hobohm 2010). This shows the importance of protecting and managing such habitats.

2.2 Africa

Africa can be divided in two large biogeographical regions, North Africa and sub-Saharan Africa. As in many other parts of the world, shrublands often represent a transition zone between open landscape units such as desert, semidesert or grassland and woodland or forest (Happold and Lock 2013).

Mediterranean shrub- and heathlands can be found in North Africa (Cowling et al. 1996). They are part of the natural vegetation e.g. above the tree line in the Atlas Mountain. Maquis and garrigue are the result of forest degradation at lower elevations between the Atlas mountain chain and the Mediterranean Sea and these habitats

are more or less strongly influenced by humans with their livestock (Quezel 1977; White 1983).

More than half of the area south of the Sahara consists of different types of savannas (Du Toit and Cumming 1999), with broad-leaved savanna in the higher regions and fine-leaved savanna in the lowlands.

The African savannas harbour the highest diversity of ungulate species (Du Toit and Cumming 1999). These animals, some of which are endemics (Turpie and Crowe 1993), control the structure of savannas by grazing and trampling.

The largest and most diverse shrubland in Africa is found in the southwest part of the continent, the Karoo-Namib region (White 1983). Dwarf shrubs and succulents are important components of the Karoo shrublands (White 1983).

The succulent Karoo biome is species-rich, and many species are regional endemics (Mucina et al. 2006). The region harbours about 6356 vascular plant species (Driver et al. 2003).

In the Cape, the heathland is known as fynbos. The species composition of the fynbos, including coastal, arid and mountain fynbos types, can be extremely diverse in the various regions of the Cape (Goldblatt 1978; Rebelo and Siegfried 1990), with some of the richest species pools in the world (Kruger 1979). The fynbos of South Africa is also a habitat for many endemic vertebrates such as the golden mole *Chrysochloris asiatica*, the geometric tortoise *Psammobates geometricus* or Victorin's warbler *Cryptillas victorini* (Bigalke 1979).

In Madagascar, dry spiny bush can be found in the southwest part of the island (Burga 2011). This habitat type is unique in terms of vegetation structure and species composition (White 1983) and many of the plant species and reptiles are endemic to the south of Madagascar (Cabanis et al. 1969). Another type of shrubland, rupicolous shrubland, is found in rocky parts of the island. Some of the mountain heathlands of Madagascar represent secondary vegetation units, which are the result of anthropogenic influence and fires (Raxworthy and Nussbaum 1996).

2.3 North America

The shrubland of the Low Arctic region of North America is dominated by species such as *Betula nana*, *Salix glauca* and *Salix pulchra*. These are often associated with grasses, mosses and Ericaceae (Bliss 1979). Arctic heathlands can be found in Alaska and Canada, where their structure and species composition are similar to those in other parts of the Arctic; they consist mainly of Ericaceae, mosses and lichens (Hanson 1953; Whittaker 1977).

The salt spray heathland, an endangered ecosystem type, is found in the coastal region in the NE of the United States of America. The influence of salt reduces the speed of succession and influences the composition of the vegetation in these heathlands (Griffiths and Orians 2003).

Vast shrublands in the USA can be found in the semi-arid region of the western part of the country (McArthur and Kitchen 2007). Huge areas in the west of the

United States are dominated by sagebrush (*Artemisia* div. sp.), with *Artemisia tridentata* one of the most widespread species (Davies et al. 2011). The relating landscape units cover about 13.3–14.5% of the total shrubland area in the USA (Xian et al. 2015).

The chaparral of California comprises shrublands under the influence of a Mediterranean-type climate. Evergreen shrubs dominate, as in other Mediterranean climate regions (Franklin et al. 2004; Hanes 1981). As part of the Mediterranean biome this habitat is species rich and harbours many endemic plant species (Cowling et al. 1996).

2.4 South America

In most regions of the continent and at all elevations below alpine zones woody vegetation dominated by dwarf shrubs, shrubs or succulents represents transitions between open vegetation and forest in space or time. Despite their species richness, the savannas of South America receive less protection and management than the Amazonian Forest (Ratter et al. 1997).

The Cerrado biome of Brazil covers about 23% of the country. The biome is dominated by grassland, shrubland, woodland, various transition zones, and harbours South America's most species-rich savanna (De Oliveira-Filho et al. 1989; Ratter et al. 1997). Many reptiles and amphibian species are endemic to the Cerrado, which also provides habitat for a great diversity of insect species (Klink and Machado 2005) as well as critically endangered animals such as the blondtiti monkey *Callicebus barbarabrownae* and glaucous macaw *Anodorhynchus glaucus* (IUCN 2019).

The llanos of Columbia and Venezuela (Medina and Silva 1990) represents the second largest savanna habitat of South America (Huber et al. 2006).

In Chile, species-rich evergreen shrubs form the matorral, which is comparable to the chaparral in California (Jaksic and Fuentes 1980; Rundel 1977). This sclerophyllous shrub habitat occurs in a Mediterranean-type climate. As part of the Mediterranean biome the matorral harbours great biodiversity (Cowling et al. 1996).

Some heathland habitat also exists in South America. Wet heathland can be found in Patagonia, where the vegetation is dominated by *Empetrum rubrum* (Moore 1979).

2.5 Oceania

In many regions of Australia climatic conditions and fire favour the development of scrubs, heathlands and transitions to woodland.

The S and W of Australia with winter rain and summer drought is home to one of the most species-rich biomes on Earth (Cowling et al. 1996). Kwongan and mallee

are landscape units of South Australia. Kwongan is a vegetation type similar to the maquis in Europe or the chaparral in California. The mallee is an open shrub vegetation, consisting mostly of *Eucalyptus* species growing on oligotrophic soil (Holland 1969; Specht 1979a, b). Many endemic species occur in both habitats. The mallee ecosystem has a diverse reptile fauna. Examples of endemic species are the mallee dragon *Ctenophorus fordi* and the southern Mallee ctenotus *Ctenotus atlas* (Menkhorst and Bennett 1989). The mallee is also the habitat of more than 100 species of birds. The red-lored whistler *Pachycephala rufogularis* and black-eared miner *Manorina melanotis*, for example, are among the birds which are restricted to this ecosystem (Schodde 1981; Keith et al. 2014).

Heathlands can be found in New Zealand. In the north of New Zealand, most heathlands are the result of deforestation (Enright 1989). Both the North and the South Island are covered partially by different types of heathland. Some are the result of anthropogenic influence and others are the result of specific environmental conditions (Burrows et al. 1979).

2.6 Asia

Asia harbours a great diversity of shrub ecosystems which all differ from those in Europe. The different habitats often merge directly into one another, with savannas and shrublands often forming a transitional stage between grassland and forest. In many cases, the savannas of Asia are not considered distinct ecosystems and are classified as degraded forest (Ratnam et al. 2016). Deciduous broadleaf savanna, fine-leafed spiny savanna and pine savanna are all found in continental regions of SE Asia (Ratnam et al. 2016). Like the savannas in Africa they provide habitat for endemic ruminant mammals, among them many rare species, such as the critically endangered kouprey *Bos sauveli*. A couple of years ago there have been only 50 individuals of this species left and the probability that this animal is already extinct is high (Timmins et al. 2016).

In Malesia, natural heathlands can be found on nutrient-poor sandy soil or above the timberline. At lower elevations, forests and heathland are not clearly delineated. In some cases, heathland species and trees coexist and form heath-forest (Specht and Womersley 1979).

The Thar Desert is a thorny shrubland in Rajasthan India (Bhandari 2005). Many endemic and rare species live in this ecosystem (Khan 1997) making it a regionally important and highly biodiverse habitat.

A high diversity of plant species is also found in the alpine shrub vegetation of the Himalaya Mountains (Chawla et al. 2008).

The arid climatic conditions of Afghanistan favour the growth of shrubland. A great variety of shrub vegetation, such as juniperus shrubland, subtropical dry scrub, and the Rhododendron-Krummholz of the higher-altitude mountain areas, is to be found in the various regions of the country (Breckle 2007).

3 Degradation and Threats to Heathland, Shrub and Savanna Habitats

The large number of critically endangered species in heath, shrubland and savanna highlight how important it is to protect and preserve these habitats.

According to the IUCN Red List, shrublands worldwide harbour 293 animal and 333 plant species that are classified as critically endangered. Savannas are the habitats of 62 critically endangered plants and 39 critically endangered animal species (IUCN 2019; assessed 6/2019). Both vertebrates and numerous invertebrates are among the critically endangered animals of these habitats.

Figures 3 and 4 show the numbers of critically endangered species that inhabit shrublands and/or savannas in different parts of the world. In the following, some examples of critically endangered animals and plant species are given to highlight the importance of these habitats for nature conservation.

An example of a critically endangered vertebrate species which is only known to exist in the shrubland of an Andean valley in Ecuador, is a reptile called Peters ameiva *Holcosus orcesi*. The number of adult individuals is unknown and the likelihood of this animal already being extinct is high (Cisneros-Heredia et al. 2017).

Another critically endangered animal species is the giant lizard *Gallotia bravoana* which inhabits shrublands on La Gomera, Canary Islands. This endemic reptile can only be found in two localities on the island. The wild population is estimated to consist of 90 individuals (Miras et al. 2009).

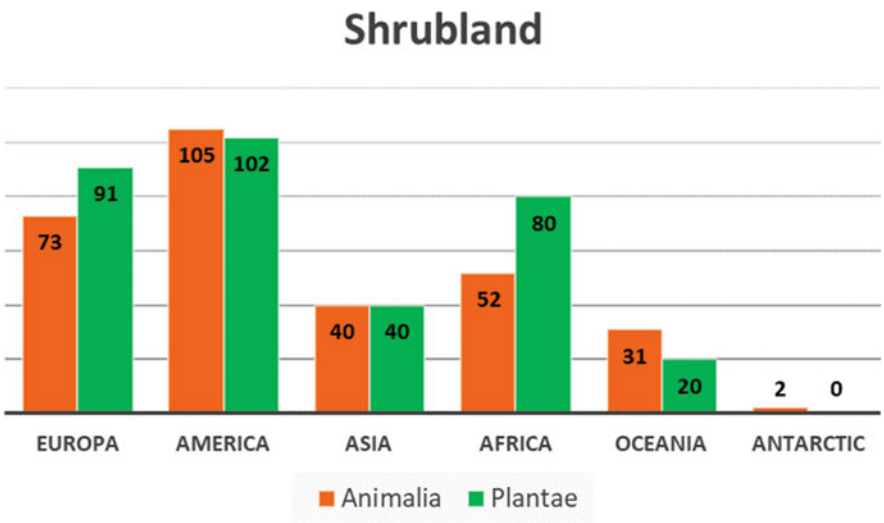

Fig. 3 Number of critically endangered species (CR) in shrublands of the various continental regions (IUCN Red List: https://www.iucnredlist.org/ 11.01.2019, illustration created by the author)

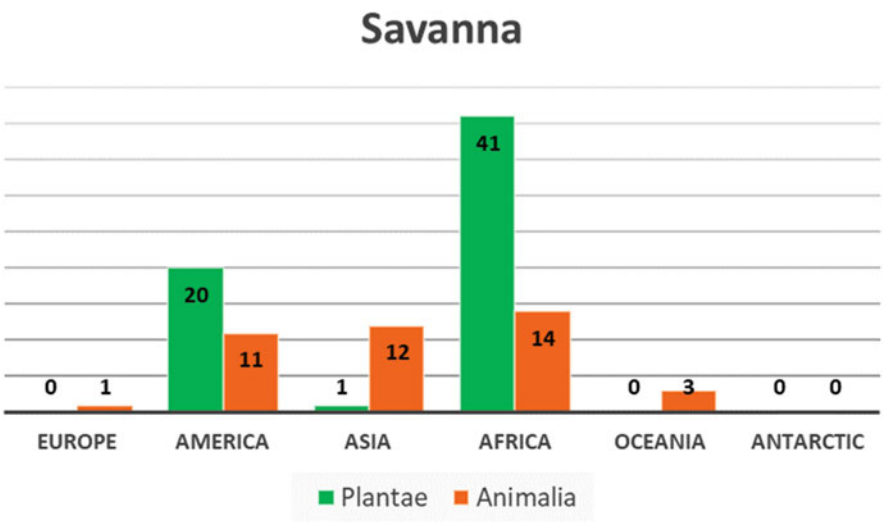

Fig. 4 Number of critically endangered species (CR) in savannas of the various continental regions (IUCN Red List: https://www.iucnredlist.org/ 11.01.2019, illustration created by the author)

The dwarf ebony *Trochetiopsis ebenus* is also considered critically endangered. This plant can be found in shrubland on Saint Helena, where only two adult individuals now remain (Lambdon and Ellick 2016).

Orthotrichum handiense is an example of a critically endangered bryophyte species. This species is endemic to the Canary Islands and the existing 50 individuals can be found only at a single location in the shrubland of Fuerteventura (Mancebo et al. 2019).

The northern hairy nosed wombat *Lasiorhinus krefftii* inhabits the savanna of Australia. The population of this critically endangered species has been estimated to consist of only c. 113 individuals (Sam et al. 2003).

Examples of critically endangered plants that can be found in savannas are: *Uebelmannia buiningii* (Brazil), *Turraea elephantina* (Kenya) and *Linderniella boutiqueana* (Burundi) (IUCN 2019).

There are many reasons for the loss and degradation of habitat around the globe. In Brazil, for example, a large area of the Cerrados has been transformed into agricultural land (Ratter et al. 1997). In South Africa, the area covered by fynbos is decreasing. Agriculture and urbanisation had already destroyed 48% of the dune asteraceous fynbos and 77% of the sandplain proteoid fynbos of the cape of Peninsula by the end of the last millenium (Richardson et al. 1995).

In Europe, most of the heathlands and shrubs are manmade and at risk due to abandonment, as this favours the growth of forests.

13% of the heathlands and shrubs described in the European Red List of Habitats (Janssen et al. 2016) are vulnerable, and a decrease in heathland areas can be observed almost everywhere in Europe. For example, 99% of Belgium's heathland areas have disappeared since 1775 (Piessens and Hermy 2006). Heathlands in

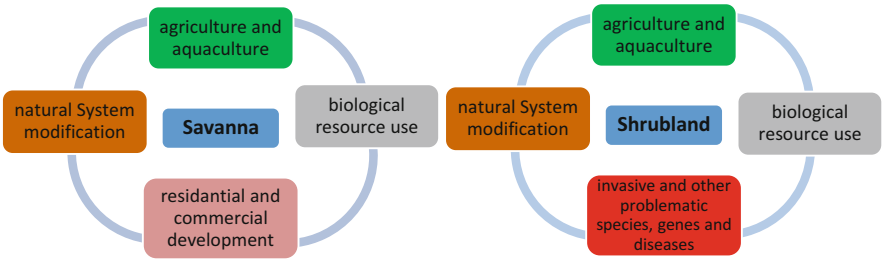

Fig. 5 Main threats to critically endangered savanna and shrubland species (IUCN 2019, illustration created by the author)

Europe today are fragmented, isolated and often surrounded by agricultural land (Webb 1998).

In Australia 30% of the heathlands are now serve other land use purposes (Keith et al. 2014).

Savanna and shrubland face similar threats globally (Tscharntke et al. 2005; Mckinney 2002; Richardson et al. 1995). According to the (IUCN 2019, assessed 6/2019), the main threats to critically endangered shrubland species are agriculture and aquaculture, natural system modifications, invasive and other problematic species and biological resource use (Fig. 5). Critically endangered savanna species are also primarily threatened by agriculture and aquaculture, biological resource use and natural system modification, but residential and commercial development poses an additional threat here (Fig. 5).

A worldwide loss of ecosystem biodiversity due to the increase of urbanisation and agricultural land can be observed. The expansion and intensification of agriculture is one of the most significant reasons for the transformation of land (Lambin and Meyfroidt 2010) and the most important factor in the loss of habitats. In the different continental regions, agriculture is a major threat to the critically endangered animals and plants occurring in shrubland and savanna habitats (Figs. 6 and 7). Globally, the expansion of small farms has a stronger impact than the agroindustry, as 90% of the farms are smaller than 2 ha (Tscharntkea et al. 2012). Not only crop and timber plantation but also grazing can be a threat to the biodiversity of these habitats. Overgrazing can cause the degradation of woody vegetation units leading to a downscaling of the vegetation structures and altering species composition. In many regions of Asia and Africa, domestic animals displace wild herbivores in grasslands and savannas (Du Toit and Cumming 1999).

Urbanisation endangers the diversity of habitats and can lead to biotic homogenisation (Concepción et al. 2015). Urbanisation and agriculture expansion lead to the fragmentation of shrublands and savannas. This, in turn, reduces the exchange between populations, thus reducing species diversity, even if the environmental conditions within the habitats are still adequate (Andren 1997).

Biological resource use, such as hunting and collection of plant material can also cause degradation of savanna and shrubland habitats. Gathering of terrestrial plants,

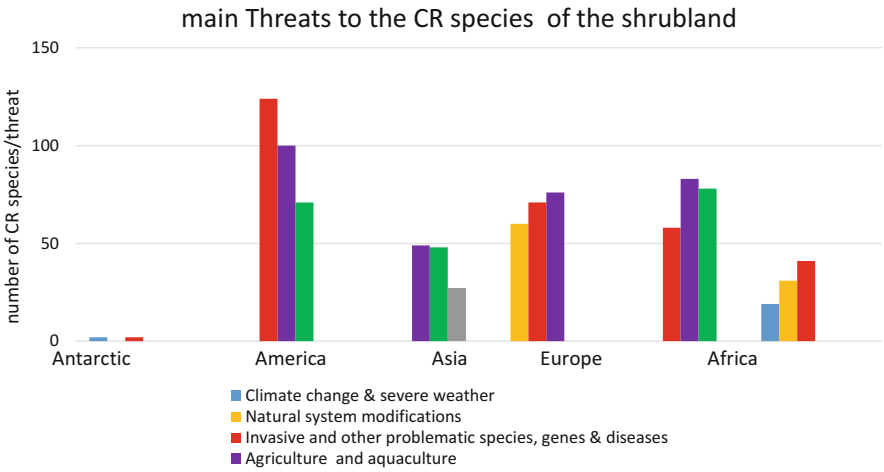

Fig. 6 Main threats to the critically endangered plant and animal species of the shrublands (IUCN Red List: https://www.iucnredlist.org/ 06.2019, Illustration created by the author)

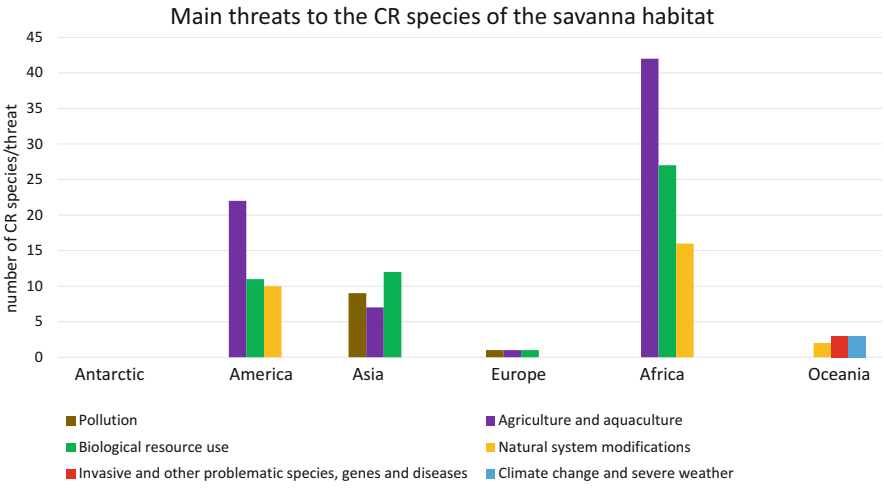

Fig. 7 Main threats to the critically endangered plant and animal species of the savannas (IUCN Red List: https://www.iucnredlist.org/ 06.2019, illustration created by the author)

logging and wood harvesting are threats to the vegetation diversity of the savannas and heathlands in several parts of the world (Figs. 6 and 7).

Natural system modifications such as fire and fire suppression and the invasion of native and alien species are non-negligible threats to species living in heath, shrubland and savanna habitats (Figs. 6 and 7).

Fires are an important factor. Depending on the regional frequency and seasonality of natural fires, the effect can be stabilisation of or damage to the natural species

composition (Glitzenstein et al. 1995). The suppression of fires in many regions of the world can have dramatic effects on natural species composition.

4 Conclusion and Outlook

Scientific awareness of habitats dominated by dwarf shrubs or shrubs is not as advanced as for forest, freshwater ecosystems, or coastal habitats, for example. In comparison with forest or wetland areas, heath and shrub habitats have received little attention in ecological research and practical nature conservation programmes.

This group of habitats harbours a huge diversity of plant and animal species with many endangered species. In most cases, they represent transitions between open landscapes and forest in space or time or are composed of different structural elements and vegetation heights. The vegetation structure of these woody habitats is often much richer than that of neighbouring habitat types.

In some cases, shrublands can provide alternative habitats for forest or grassland species if these habitats in the neighbourhood are destroyed.

Thus, increased appreciation of these types of landscapes and habitats in science and nature conservation practice might help to find solutions for protecting the natural biodiversity.

Appreciation can mean, for example, recognition, mapping, and protection of the respective habitat types.

Large areas of arable land where woody structures have already been completely destroyed might be given more value allowing space for small strips along the fields for natural succession or establishment of hedgerows, for example.

The heathlands, shrublands and savannas of the world include unique and diverse ecosystems; these habitats harbour many rare and endemic plants and animals. However, loss and degradation of heathlands, savannas and shrublands can be observed worldwide, in both developing and industrial countries.

Many heathlands have soils with low or very low nutrient contents. It is not easy to protect oligotrophic conditions in regions with an input of eutrophic substances such as NO_x from the atmosphere or agriculture. However, different courses of action have been successfully tested to protect heathland in many regions of Europe.

The savannas also face many environmental and conservation problems. Desertification is often the result of intensive grazing and too many domestic animals (Sivakumar 2007), leading to a decrease in woody plant cover, as for example in West Africa (Thiollay 2006). Most likely, some savannas will continue to degrade and will transform into deserts.

Changing use intensities and global warming result in a shift of vegetation zones and change of distribution patterns, and a migration of scrub zones to the North can already be observed (Tape et al. 2012). If temperatures continue to rise, subarctic shrubs and heaths may immigrate into areas where conditions were previously unsuitable. In the United States of America, for example, shrubs are encroaching

into the prairie, due to changes in land use. A savanna-like ecosystem with a mixture of grasses and shrubs has developed here (Briggs et al. 2005).

With the growth of population in Asia and Africa, urbanisation is increasing (Boadi et al. 2005). If this trend continues, many ecosystems will be affected due to the expansion of cities.

Both native and alien invasive species can cause problems for rare, threatened and endemic plant and animal species. Islands in particular seem to be sensitive to this problem (Reaser et al. 2007). It is possible that the dispersal of invasive species also influences the distribution of heathlands and shrubs. In Western Europe, native and non-native tree species can occupy the coastal heathlands and change the characteristics of a whole ecosystem (Saure et al. 2014). However, these invasions are often accompanied by changes in or abandonment of traditional use.

Fertilization often causes the extinction of plant species and the related food webs which are adapted to nutrient-poor conditions. This is the case in many European heathlands. The higher availability of nitrogen associated with the abandonment of traditional use results in the decrease of ericoid shrubs and the propagation of grass species (Terry et al. 2004). The higher nitrogen availability in heathlands can lead to nitrogen-limited plant growth becoming phosphorus limited (Haerdtle et al. 2009). Changes in nutrient availability should be taken into consideration in future management of heathlands, as different management practices affect the availability of nutrients in the ecosystem (Diemont et al. 2013).

To preserve the biodiversity in these habitats, a number of protection and conservation measures need to be taken.

This goal cannot be achieved by protecting only small, fragmented areas. In Africa, the protected areas are insufficient to assure the survival of many endemic animal species, as many of these species are migrants (Western and Ssemakula 1981). The management of non-protected areas can play an important role in the conservation of the savanna habitat and its endemic species. This is, for example, the case in Kenya's Pro-wildlife ranges where wildlife conservation and extensive cattle grazing coexist (Georgiadis et al. 2007).

In many developing countries poverty and the lack of resources can lead to further degradation of the ecosystems. The savannas and shrublands of developing countries can be affected by this problem. In some cases, this is described as a "downward spiral": poverty, the overuse of resources and environment degradation influence each other (Scherr 2000). Poverty reduction, better management of resources and environment education can help to preserve the diversity of ecosystems.

In Europe, fragmentation and rapid decline of heathland areas can be observed, and effective management is needed to maintain the last intact areas. The actions needed depend on the area. In many cases, characteristic heathland has been successfully restored by removing vegetation and the fertilized top soil, with heathland occurring again after a couple of years of succession. In Dorset, UK, for example, a variety of management actions were applied to restore heathland from pioneer succession (Mitchell et al. 1999). A sustainable use of the habitat, such as sustainable honey, meat and wool production, might be a solution. The management actions required depend strongly on the specific ecosystem.

There is major debate on whether humans should manage the ecosystems or not. Without the intervention of humans, succession would in many cases result in woodland with lower species diversity (Maher et al. 2010). A mosaic of different habitat types composed of half-open landscapes might be most successful with respect to the conservation of high biodiversity. The conservation and management of heathlands, savannas and shrubs should be considered a priority because these landscapes are highly biodiverse and provide habitat for many endemic species.

Similar problems and threats seem to endanger the biodiversity of these habitats all over the world.

The future of heathlands, savannas and shrublands is difficult to predict. They are very dynamic ecosystems so it is possible that in some place these habitats will disappear, and with them many plants and animals. The large number of critically endangered species that live in shrublands and savannas highlights the importance of these habitats. However, they require not only protection but also management.

A mosaic of different ecosystems, which must include heathlands, savannas and shrubland, is important to assure high biodiversity.

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