EUROPEAN REEDBEDS

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CLASSIFICATION

International: In a strict sense, reedbeds refer to plant formations dominated by common reed *Phragmites australis*. Environmental perception of reedbeds varies according to continents and haplotypes (Marks et al. 1994; Güsewell & Klötzli 2000; Ludwig et al. 2003), as well as other biota associated with the dominant species. Hence, the reedbeds of Europe are regarded as a different ecosystem to those dominated by the same species on other continents.
National: Following the abundance and colonisation abilities of *Phragmites australis*, reedbeds have not been included in the European Habitat Directive. However, owing to their specific and vulnerable fauna, they are often listed as Wetlands of International Importance under the Ramsar convention or as Special Protection Areas under the European Union Bird Directive, being a priority habitat under the Biodiversity Action Plan in UK. In Europe, reedbeds are often referred to as a "priority species habitat."
IUCN Habitats Classification Scheme (Version 3.0): 13 Marine Coastal/Supratidal / 13.4 Coastal Brackish/Saline Lagoons/Marine Lakes

ECOSYSTEM DESCRIPTION

Characteristic native biota

Reedbeds are floristically impoverished ecosystems providing low niche diversity but high carrying capacity for wildlife. The dominant plant species, *Phragmites australis*, determines the structure of the system. It is often found in association with other species from the following plant genera: *Bolboschoenus*, *Carex*, *Glyceria*, *Juncus*, *Phalaris*, *Scirpus*, *Spartina* and *Typha*. These tall helophytes provide a sheltered and nutrient-rich habitat to various arthropods, birds and fish (Ward 1992; Hawke & Jose 1996; Okun & Mehner 2005; Self 2005; Valkamaa et al. 2008; White et al. 2006).

Figure S6. 1. Reedbeds in summer (left) and winter (right).

In Europe, reedbeds are the only or major breeding habitat of several vulnerable or endangered bird species at European level (eg., Eurasian bittern *Botauraus stellaris*, Purple heron Ardea purpurea, Little bittern Ixobrychus minutus, Moustached warbler *Acrocephalus melanopogon*), as well as the major migrating habitat of the globally vulnerable Aquatic warbler *Acrocephalus paliducola* (Provost et al. 2010). Several bird species further use predominantly reedbeds for nesting, feeding, resting and/or moulting during at least some part of the year (Bibby & Lunn 1982; Smiddy et al. 2007; Broyer & Calenge 2010).

Figure S6. 2. A great reed warbler *Acrocephalus arundinaceus* in the Camargue.

Abiotic environment

Common reed can colonize a wide variety of permanent, semi-permanent and temporary wetlands: deltas, marshes, lake belts, edge of river and channels, roadsides and ditches. It is typically found in stagnant to slow-current fresh or brackish (0-22 ‰) shallow (0 – 1.5 m) waters. Factors limiting common reed occurrence and expansion are primarily water depth, current or waves, hypertrophic and hypersaline conditions (Engloner 2009). Under optimal conditions, common reed tends to form monospecific and productive stands.

Distribution

Present on all continents except Antarctica, common reed is probably the most widely distributed flowering plant on earth. The geographic distribution of Eurasian bitterns, a reed-specialist heron, provides a good approximation of reedbed distribution in Europe (Fig. 3).

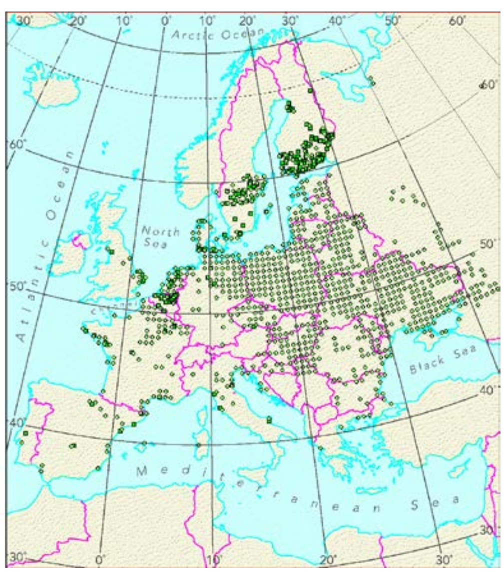

Figure S6. 3. Distribution of Eurasian bitterns (circles) and of Special Protection Areas (squares) in Europe. Source: http://www.eea.europa.eu/legal/copyright.

Key processes and interactions

Common reed may be established from seed, but spreads mainly by a rhizomatous root that extends both horizontally and vertically. The green growth of the plant provides the rhizome with food and oxygen during the summer. During the winter, standing dead stems bring oxygen to the rhizome. Reedbeds are characterized by a high primary productivity that permits rapid vegetative expansion and often lead to accumulation of organic matter and evolution towards woodlands. The presence of an autogenous soil made of rhizomatous roots and accumulated organic matter contributes to rising ground level or creates floating soils. The plastic morphology of reed stems and the capacity of rhizomes to accumulate reserves increase the plant's resistance to stress (Engloner 2009). Bacterial activity around the rhizomes, through aerobic and anaerobic processes, confers good properties to the plant for water purification (Chu & Zhang 2006; Stamati et al. 2010).

Threatening processes

Many reedbeds have been preserved or created because they provide services to humankind including fibre (roof thatch) and food (waterfowl hunting marshes, fishponds, pasture land), but also water purification, shoreline stabilization, water retention and flood control. The main cause of reedbed regression in the first part of the 19th century was land drainage and conversion for urban and agriculture development (Everett 1989; White et al. 2006). Main current threats are natural succession (terrestrialisation) processes that are not compensated by colonisation of new areas, stabilisation and rising of water levels translating into eutrophic and anoxic conditions, as well as increased salinity associated with sea level rise in coastal areas.

Main factors threatening the reedbed ecosystem in terms of geographic distribution, abiotic substrate, biotic interactions and reversibility are outlined in Table 1. Socioeconomic uses are not considered as threats, but their intensification can affect the ecosystem negatively and they were hence included in the table.

Ecosystem collapse

For assessment of criterion A and B, European reedbeds were assumed to have collapsed when their mapped distribution declines to zero, due to either replacement by development, such as agriculture, channelization or urban infrastructure, or by a terrestrial ecosystem through succession, rendering if unsuitable for the native characteristic biota. Flow regimes and levels of pollutants would be suitable variables for assessing abiotic degradation under criterion C if data were available. Abundance of reed-dependent birds and fish were identified as suitable variables for assessing disruption of biotic processes and under criterion D. Ecosystem collapse was conservatively assumed to occur if the abundance of these organisms declines to zero.

ASSESSMENT

Summary

Criterion	A	B	C	D	E	overall
subcriterion 1	VU	LC	DD	VU(VU-EN)	DD	VU(VU-EN)
subcriterion 2	DD	LC	DD	DD		
subcriterion 3	VU	LC	LC	LC		

Criterion A

Current decline. Declines of reedbeds have been reported in several European countries, such as UK (Bibby & Lunn 1982; Boar et al. 1989), Spain (Paracuellos 2008), Italy (Fogli et al. 2002), Germany (Sukopp & Markstein 1989; Kubín & Melzer 1997), Switzerland (Krumscheid et al. 1989), the Netherland (Graveland 1998), Hungary (van der Putten 1997), and the Czech Republic (Čížková et al. 1996; Šantrůčková et al. 2001) over the last few decades. Ostendorp (1995) reported reed dieback in 35 European lakes ranging from 18 to 94% (mean 53%). Although remotely-sensed techniques have recently been developed for mapping reedbed areas and ecosystem attributes (Davranche et al 2010; Poulin et al. 2010), information on reedbed loss is generally qualitative or restricted to local areas if quantitative. UK is one of the few countries providing an overall estimate of reed area (5000 ha at 900 sites) with 45% loss reported since 1945. In France, reed area has been estimated to 39 000 ha spread over 1048 sites (Le Barz et al. 2009), but data on reed regression is only indirect through the disappearance of Eurasian bitterns, a reed-specialist heron, from 29 out of 46 departments over the 1970-2008 period. A recent estimation of reedbed area by photo-interpretation in the Danube Delta, which encloses the largest European reedbed, reported 220 000 ha, which could represent a 22% decrease compared to previous reports of 284 000 ha. In Spain, a reported 56% loss in reedbeds from a small wetland in Almeria province due to agriculture (greenhouse) development is believed to be representative of the whole country, which has lost at least 60 % of its wetland surface, mainly coastal, over the last 200 years (Casado & Montes, 1995). In Germany, reedbeds are considered as vulnerable according to the National habitat red list (Riecken et al. 2006). In Austria, the largest reed area (lake Neusiedler See region) has increased from 1009 ha to 3016 ha between 1855 and 1993 following a stabilisation of the water table and cessation of extensive grazing (Kohler et al. 1994). However, this site is not considered as representative of the whole country which has lost 90% of its wetlands since the mid 19th century. Most of these estimates from different countries suggest reedbed losses of at least 30% over the past 50 years and a few exceed 50 % decline in distribution. Overall, the decline in distribution across Europe is therefore likely to be exceed 30%, but likely to be less than 50% over the past 50 years. Therefore the status of the ecosystem under criterion A1 is Vulnerable.

Future decline. Salt intrusion in coastal areas, litter build-up in continental areas, water pollution and eutrophication processes in large lakes and deltas are likely to continue in the next few decades, further contributing to reedbed regression in spite of increased conservation and protection measures. Water level stabilisation that prevents colonisation of new areas is also expected to continue, with reedbed restoration and creation not compensating for these losses owing to the small areas they involve. This could lead to a further decline of at least 30% over the next 50 years, however at present there are no quantitative estimates projecting future distribution and the status of the ecosystem is Data Deficient under criterion A2.

Historic decline. Land drainage and reclamation for agricultural and urban development has resulted in major wetland loss for most European countries since 1750. Although declines that occurred prior to the last 50 years are not well documented, reedbed destruction due to land drainage was the dominating threat before 1960, and estimates available for some countries (e.g. Austria) suggest substantial land drainage and reclamation since the mid 19th century, while in a number of countries (e.g. UK), the decline over the past 50 years alone is close to, or greater than 50%. Hence, the decline in distribution since 1750 is likely to be ≥ 50% and the status of the ecosystem under criterion A3 is Vulnerable.

Criterion B

Extent of occurrence. The ecosystem has an extent of occurrence encompassing Europe's total area (10,180,000 km^2), even though there is evidence of continuing decline and serious threats (Table 1). As the distribution of the ecosystem exceeds the thresholds for extent of occurrence, its status under criterion B1 is Least Concern.

Area of occupancy. Total reedbed area is estimated to be between 5000 and 10 000 km^2 in Europe. This area is dispersed widely across many wetlands. Area of occupancy (AOO) would therefore exceed 100 10 × 10 km grid cells, even excluding cells that contain small occurrences that cover less than 1% of cell area. The status of reedbeds under criterion B2 is thus Least Concern.

Locations. Reedbeds are naturally patchy ecosystems, colonising various habitat types and are found at many hydrologically independent locations. Hence their status under criterion B3 is Least Concern.

Criterion C

Current decline. Causes of degradation of the physical environment are diverse, involving reduced hydroperiod due to sediment/litter build up, decreased water quality resulting from industrial development, increased water eutrophication following agricultural development and stabilisation of water levels with reduced water flow. Embankment is a major large-scale problem threatening ecological functions of reedbeds. For instance, 59 dams were build along the first 1000 km of the River Danube for hydropower plants, with over 700 dams and weirs along its main tributaries. As a result, 100 000 ha of reedbeds were embanked for flood protection. In the Danube Delta the reduced flows and embankment prevent the refreshment of water in the limans (small estuary lagoons) by rising and falling water levels, reduces the filtering of silt, nutrients and pollutants in the Danube waters as well as the fertilization of the floodplain by floods. It also contributes to the salinisation of the nearby agricultural polders, and in combination with river dredging, halt key geomorphological processes (sedimentation) increasing risk of delta drowning by the sea. However, quantitative estimates of these processes are currently unavailable and the status of the ecosystem under criterion C2 is Data Deficient.

Future decline. Increased management and protection of remaining reedbeds, as well as improved water quality will hopefully refrain degradation of the physical environment in the future. Some 15% of the Danube Delta has been restored by partial dyke removal. However, increased salinisation caused by sea level rise is expected to threaten many coastal reedbeds in the next 50 years and more. Because quantitative projections of these processes are currently unavailable, the status of the ecosystem under criterion C2 is Data Deficient.

Historic decline. Reedbed destruction (land drainage) was the dominating threat before 1960. Factors affecting the physical environment of remaining reedbeds (embankment, intensification of uses, water pollution) had a lower extent and severity historically than over the past 50 years. Hence it is unlikely that the extent and severity of environmental degradation exceeds 70% since 1750 and the status of the ecosystem under criterion C3 is Least Concern.

Criterion D

Common reed is relatively tolerant to reduced flooding periods, embankment and water pollution. However, reduced quality and quantity of waters directly affect the aquatic flora and fauna, which are crucial component of the food web. Shorter flooding period from June to December has been shown to reduce abundance of invertebrates and passerines the next spring (Poulin et al. 2002). Nesting birds are particularly sensitive to water level and a water shortage in early/late spring will translate into the desertion of breeding sites/lower breeding success of heron and duck species (Barbraud et al. 2002; Poulin et al. 2005). For example, Eurasian bitterns, a reed-specialist heron, disappeared from 29 out of 46 departments in southern France over the 1970-2008 period (Poulin et al. 2005). In this area, the complete disappearance of this key reedbed species represents a disruption to biotic interactions of 100% severity across 63% of the sampled extent. Embankment results in loss of habitat connectivity, reducing spawning areas for fish (Self 2005; Kallasvuo & Urho 2011). In the Danube Delta, a major centre of reedbed distribution, drainage, water regulation and pollution all had drastic effects on the waterbirds and fish, resulting in population decreases in 20 bird species (Schneider 1990), and the collapse of migratory anadromous sturgeons (Huso huso, Acipenser güldenstaedti and Acipenser stellatus) fisheries from 1000 tons/year at the beginning of the 20th century to 10 tons/year in 1990. Sedimentation and anoxia can further increase the impact of grazing by exogenous invasive mammals such as nutria Myocastor coypus (Boorman & Fuller 1981). Overall, the large declines in waterbird populations at two major centres of reedbed distribution, suggest a decline in biotic interactions with a relative severity of at least 50% over at least 50% of the extent of the ecosystem, with some biota declining by up to 90% in parts of the ecosystem distribution. The status of the ecosystem under criterion D1 is therefore Vulnerable (plausible range Vulnerable - Endangered).

Future decline. Disruption or decoupling of biotic interactions is not expected to decrease in the following 50 years. Salinisation of coastal reedbed will lead to a decrease in reed biomass and reduction in number of aquatic species. Intensification of reed exploitation is a likely scenario considering the increased demands for energy crop and renewable eco-material for green buildings. Overall decrease in bird and fish abundances could further lead to cascading effects (Tscharntke 1992; Mancinelli 2002; Xiong et al. 2010). However, quantitative projections of these processes are not currently available, and the status of the ecosystem under criterion D2 is Data Deficient.

Historic decline. Factors affecting biotic interactions, besides habitat destruction, had a lower extent and severity historically than over the past 50 years. Hence it is unlikely that the extent and severity of disruption to biotic interactions exceeds 70% since 1750 and the status of the ecosystem under criterion D3 is Least Concern.

Criterion E

No quantitative analysis has been carried out to assess the risk of ecosystem collapse for European reedbeds. The status of the ecosystem is therefore Data Deficient under criterion E.

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Table S6. 1. Identification of major threats affecting the reedbed ecosystem with their relation to the Red List Criteria assessment

							Intensification of socioeconomic uses			
Ecosystem threats	**Drainage**	**Natural succession process**	**Xenobiotic water pollution**	**Increased water level or nutrient inputs**	**Sea level rise**	**Embankment**	**Fish farming**	**Waterfowl hunting**	**Grazing & summer mowing**	**Reed harvesting**
Reduction in geographic distribution	Reed stands replaced by agricultural land and urban fabric	Evolution of reedbeds towards woodland	Little effect on reed area owing to reed resistance to pollution	Reed regression leading to disappereance within one or two decades under severe conditions	Evolution of coastal marshes into lagoons with reedbed disappearance above 20 g/L surface water	Major perturbation increasing risks of agricultural conversion	Reduction of reed belt in fishpond	Increased open water areas at the expense of reed	Unsustainable practices reducing reed area and dominance	No reduction in reed area, reed tolerant to winter cutting, beneficial for refraining litter accumulation
Degradation of abiotic substrate	Complete loss of ecosystem substrate	Reduction in flooding period through litter/sediment build up	Poor water quality	Water eutrophication and anoxia, thick mud layer with undecomposed vegetal matter	Salinisation of surface/ground waters	Stabilisation of water levels, reduced water flow and oxygenation, reduced water quality (purification)	Reduced drawdown frequency, h increased eutrophication, absence of gradual slopes	Permanent flooding with increased water eutrophication	Compacted, less oxygenated ground for grazing and mechanical cutting	Soil compaction and risk of root damage if cutting engines not adapted to ground softness
Disruption of biotic interactions	Complete disruption of reedbed biotic interactions	Loss of aquatic organisms and of the reed-specific fauna	Reduced richness and abundance of aquatic organims and their predators	Reduced foraging and nesting opportunites for birds, impoverishment of the aquatic flora and fauna	Reduced reed biomass starting at 5 g /L, impoverishment of the invertebrate aquatic fauna	Decrease in reed density and vigor, reduction of spawning areas for fish.	Degradation of hydrophyte beds, reduced fish species & trophic guild richness with consequences on birds	Degradation of hydrophyte beds, reduction of foraging and nesting opportunities for nongame birds	Reed replaced by less palatable or summer-cutting tolerant species with loss of typical reed fauna	Loss of dry reed as refuge to the wintering fauna, reduced opportunities for breeding birds in spring
Proxys	Modification of land use	High ratio of dry to green stems, litter thickness, scrub encroachment.	Water quality	Presence of green algae, dark/ smelly water, reeds in tussocks with floating, unattached rhizomes	Surface and underground water salinity	Dyke	Vertical slopes of ponds, reed belt limited or absent	Artificially created open water areas, low richness of submerged macrophytes	Loss in reed height and multiplication of side-shoots before reed disappearance	Large areas with only green (growing) reeds in spring-summer
Reversibility	Irreversible, but partially compensated by reedbed creation in small areas	Irreversible without soil scraping, formally compensated by colonisation of new areas	Regulations expected to improve water quality	Reversible with summer drawdown	Locally reversible with improved management (freshwater input)	Restauration possible by dyke (partial) removal	Promotion of sustainable practices, bank reprofiling	Promotion of sustainable practices with periodical short drawdown and maintenance of a 50% reed area	Promotion of extensive grazing (0.5 cattle/ha) not followed by flooding, summer cutting in mosaics	Promotion of sustainable practices with maintenance of a mosaïc of harvested/non harvested patches