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Phragmites australis swamp and reed beds

MarLIN – Marine Life Information Network
Marine Evidence–based Sensitivity Assessment (MarESA) Review

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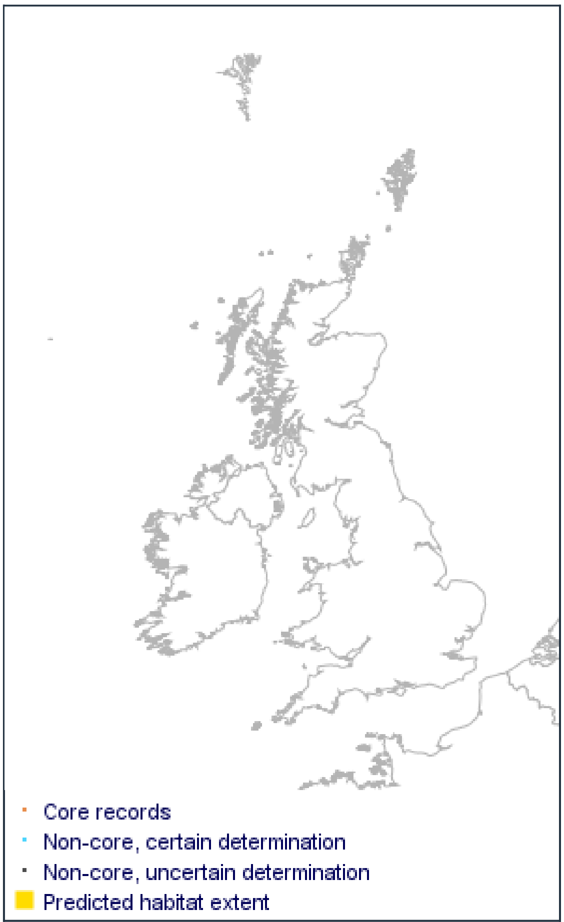
Edge of a *Phragmites* reed bed in February, Tamar Estuary.
Photographer: Harvey Tyler-Walters



17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Dr Harvey Tyler-Walters **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A5.541	Vegetation of brackish waters dominated by *Phragmites australis*
JNCC 2015	SS.SMp.Ang.S4	*Phragmites australis* swamp and reed beds
JNCC 2004	SS.SMp.Ang.S4	*Phragmites australis* swamp and reed beds
1997 Biotope	SS.IMU.Ang.S4	*Phragmites australis* swamp and reed beds

Description

Permanently low salinity muds or peaty muddy sands with some gravel which supports *Phragmites australis* reed beds. These reed beds are often found in enclosed water bodies influenced by freshwater inflow and may have notable quantities of decaying reed material. The substratum may be mixtures of mud, peaty mud, sand and some gravel. Filamentous green algae and charophytes such as *Lamprothamnium papulosum* and *Chara aspera* may also be found in association with this biotope as well as a the freshwater quillwort *Myriophyllum* spp. The infaunal component of this biotope is poorly known. This biotope is further described as NVC S4 (Rodwell, 1995). (Information taken from the Marine Biotope Classification for Britain and Ireland, Version 97.06: Connor *et al.*, 1997a, b).

Depth range

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Additional information

The ecology of *Phragmites* dominated reed beds has been well studied and has an extensive literature. The following review summarizes some of the major papers, reviews and texts to which the reader should refer for further detail (e.g. Haslam, 1972; Ranwell, 1972; Haslam, 1978; Fuller, 1982; Mook & van der Toorn, 1982; van der Toorn & Mook, 1982; Fojt & Foster, 1992; Ward, 1992; Rodwell, 1995; Hawke & José, 1996). An extensive literature review is given by EUREED (1999). The following review emphasizes information from coastal, estuarine or brackish water habitats.

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Habitat review

Ecology

Ecological and functional relationships

The terrestrial animal and plant communities of *Phragmites* reed beds have been well studied (Haslam, 1972; Ranwell, 1972; Haslam, 1978; Fuller, 1982; Cowie *et al.*, 1992; Ditlhogo *et al.*, 1992; Fojt & Foster, 1992; Ward, 1992; Rodwell, 1995; Hawke & José, 1996), while the aquatic community, especially invertebrates, has been less well studied (Arnold & Ormerod, 1997) and the benthic infauna are poorly known (Connor *et al.* 1997a). In the information that follows inferences concerning ecological relationships have been made from other aquatic communities (see IMU.NVC_A12 or IMS.Rup) where appropriate.

- *Phragmites australis* forms extensive perennial systems of rhizomes that bind, oxygenate and stabilize the sediment.
- The rhizomes, litter and upright stems of *Phragmites australis* provide a substratum for a wide variety of microalgae, macroalgae, aquatic invertebrates, terrestrial invertebrates and amphibians, and substratum and nesting material for some birds (e.g. the reed warbler *Acrocephalus scirpaceus* and the bittern *Botaurus stellaris*) and the harvest mouse (*Micromys minutus*).
- *Phragmites australis* and other aquatic macrophytes or helophytes (e.g. the common marsh bedstraw *Galium palustre*, bogbean *Menyanthes trifoliata*, and the spear-leaved orache *Atriplex prostrata*) provide primary productivity within the biotope and are fed on by numerous phytophagous insects.
- *Phragmites australis* is fed on directly by numerous species of Lepidoptera (butterflies and moths), Diptera (flies), Hymenoptera (bees and wasps), Coleoptera (beetles), Homoptera (true bugs and aphids), and Acari (mites). Notable examples include, the large wainscot *Rhizedra lutosa*, the twin-spotted wainscot *Archanara geminipunctata*, Fenn's wainscot *Photedes brevilinea*, the reed leopard moth *Phragmataecia castaneae*, the gall forming midge *Giraudiella inclusa*, gall-forming flies e.g. *Lipura* spp., and aphids such as *Hyalopterus pruni* (for details see Haslam, 1972; Ditlhogo *et al.*, 1992; Tscharntke, 1992, 1999; Fojt & Foster, 1992; Hawke & José, 1996; Drake, 1998).
- Short, young shoots or rhizomes of *Phragmites australis* may be grazed by sheep, deer, water voles, some species of wild birds (e.g. Canada or grey lag geese) (Haslam, 1972, Hawke & José,1992; Rodwell, 1995).
- Additional primary productivity is provided by benthic microalgae (Wainright *et al.*, 2000), microalgal (e.g. blue-green algae and diatoms) periphyton and epiphytes growing on the stems of *Phragmites australis* (Müller, 1999), a mat of filamentous algae (e.g. *Ulva prolifera* and *Cladophora* spp.) in more saline situations and, when present, stoneworts (e.g. *Chara aspera* and *Lamprothamnium papulosum*) (Connor *et al.*, 1997a).
- Decomposition of leaves and stems, especially in autumn and winter, support a detrital food chain within the biotope and probably also provide primary productivity to deeper water and the strandline. Wainright *et al.* (2000) suggested that *Phragmites australis* contributed secondary productivity to aquatic food webs in tidal marshes (see productivity below).
- The most important role in the food chain for isopods (e.g. the water louse *Asellus aquaticus*, the isopod *Sphaeroma rugicauda* and the wood louse *Philoscia vittata*) and gammarids (e.g. *Orchestia* spp., *Gammarus zaddachi* and *Gammarus duebeni*) is the break down of decomposing leaves, stems and other plant material into fine particles of detritus

suitable for suspension and deposit feeders and microbes in the detrital food chain (Hawke & José, 1996; Arnold & Ormerod, 1997; Fell *et al.*, 1998). Other decomposers include midge larvae, nematodes, oligochaetes (e.g. *Heterochaeta costata*) and Collembella (spring tails).

- The periphyton, epiphytes and algal mats may be grazed by gastropods (e.g. *Hydrobia ulvae* and *Potamopyrgus* spp.), amphipods (e.g. *Gammarus salinus* and other *Gammarus* species), isopods (probably *Jaera* spp., and *Idotea* spp.), probably mysids (Mauchline, 1980), and tadpoles where present.
- Suspension feeders filter both phytoplankton and detritus (organic particulates), for example amphipods (e.g. *Corophium volutator*), the mysids, the epiphytic bryozoan *Conopeum seurati* where present (see Bamber *et al.*, 2001), and some polychaetes (e.g. *Hediste diversicolor*).
- Surface and infaunal deposit feeders probably include oligochaetes (e.g. *Heterochaeta costata*), amphipods (e.g. *Corophium volutator*), and chironomid larvae.
- Small aquatic invertebrates and fish fry or larvae are probably preyed on by small mobile predators such as dragonfly larvae, water boatmen (e.g. *Sigara* spp.), mysids, shrimp (e.g. *Crangon crangon*), and small fish such as sticklebacks e.g. *Gasterosteus aculeatus*).
- The larva of the silky wainscot *Chilodes maritimus* preys on the pupae of other reed moths.
- Other fish such as the gobies and the eel *Anguilla anguilla* are generalist predators.
- Mysids, shrimp (e.g. *Crangon crangon* or *Palaemonetes varians*) and crabs probably act a scavengers within the biotope.
- The terrestrial and aquatic macroinvertebrate population probably supports a variety of fish species, which enter the habitat from shallow water or with the tide, and a variety of bird species from the surrounding area.
- Small fish such as sticklebacks, minnow, fish fry, together with frogs may be important food sources for the bittern or grey heron (Hawke & José, 1996).
- Terrestrial insects are probably food sources for frogs, birds and small mammals, both within the reed bed and the surrounding area. For example, chironomids (midges) are an important food source for warblers and bearded tit (*Panurus biarmicus*), while aphids are an important food for migratory warblers, e.g. the sedge warbler *Acrocephalus schoenobaenus*. Water voles and water shrews are common on ditches and the harvest mouse may reach high numbers in reed beds feeding on insects in summer and seed (including *Phragmites* seed) in winter (Hawke & José, 1996).
- Where present the otter (*Lutra lutra*) may feed on frogs and fish, while the grass snake (*Natrix natrix*) feeds primarily on frogs (Hawke & José, 1996).

Competition

In saline and brackish conditions *Phragmites australis* competes with other halophytic plants e.g. cord grasses *Spartina* spp. at its seaward limit, where conditions favour *Spartina* species (Ranwell, 1972). In drier areas of marsh *Phragmites* may be out-competed by bulrush *Typha latifolia*, the common club rush *Schoenoplectus lacustris*, Buck's horn plantain *Plantago coronopus* or the slender sedge *Carex lasiocarpa* (Haslam, 1972). However, in areas of habitat disturbance, where for example *Spartina* spp. is removed, *Phragmites* may invade the habitat (Amsberry *et al.*, 2000). Once established, *Phragmites australis* is tall and a dominant competitor for light, so that dense stands of the common reed tend to be species poor in other plant species (Haslam, 1972; Rodwell, 1995; Bertness *et al.*, 2002). But *Phragmites* itself may be suppressed by shading (Haslam, 1972), presumably by shrub and trees (e.g. alder or willow carr) at the inland edge of the shore.

Seasonal and longer term change

Phragmites australis is an rhizomatous perennial producing annual aerial shoots that die back in winter. Young shoots begin to emerge from late March to late April for about 1-3 months (depending on conditions), reaching maximum shoot density by June to July (Haslam, 1972; Rodwell, 1995). Large buds shoot first producing larger, taller shoots that are more likely to flower than the later, smaller and shorter shoots. Shoot growth is curtailed by cooler temperatures after September. Inflorescences emerge from shoots between late July and early August and flower about a month later. Fruit develop in November and seeds are shed through winter and spring. During summer, nutrients are cycled to the rhizomes, accompanied by renewed growth of the horizontal rhizome system. In late summer, as underground food reserves reach a maximum, the rhizomes produce horizontal shoots that turn up to the surface of the substratum, forming dormant buds. Most buds form before winter ready to produce the new growth of aerial shoots in the following season. As summer progresses the aerial stems harden and leaves begin to die so that by January most leaves have fallen and stems are dead and brittle. Stems can remain standing for 2-3 years, after which they break close to the surface of the ground leaving a stubble and a litter of fallen stems (Haslam, 1972; Rodwell, 1995).

Phragmites australis first flowers after 3-4 years in moderately good conditions and individual rhizomes live for only 3-6 years, dying from behind (Haslam, 1972). However, the *Phragmites* community can be very long-lived if not disturbed, and vegetative clones of *Phragmites australis* can be up to 1000 years old (Rudescu *et al.*, 1965 cited in Rodwell, 1995).

Growth of filamentous algae and algal mats is greatest in the summer months. The aquatic and terrestrial invertebrate populations probably vary seasonally, peaking in numbers during spring and summer when the aerial shoots are growing. Some species overwinter as pupae in the dead stems of the common reed e.g. the reed leopard moth *Phragmataecia castaneae*, while others probably use the reed as an attachment for their pupae. Gall forming midges overwinter in the galls formed on *Phragmites* (Tscharntke, 1992), emerging to infest summer shoots of the reed.

The aquatic invertebrates of *Phragmites* reed beds may show similar seasonal change to those reported in *Potamogeton* and *Myriophyllum* beds in Portugal (see IMU.NVC_A12) (Cunha & Moreira, 1995). They reported that polychaetes showed little seasonal changes in abundance while molluscs and leeches showed high densities in spring to summer but low numbers or even absence in autumn to winter. Crustaceans (e.g. gammarids) were most abundant in autumn, while insects were rare but abundant in winter and summer. Oligochaetes were most abundant in winter, although some species of oligochaete were also abundant in spring. Seasonal changes in the macrofauna was related to seasonal changes in temperature, dissolved oxygen, tidal regime and low or high rainfall and hence freshwater runoff and salinity (Cunha & Moreira, 1995).

Phragmites reed beds may be grazed by Canada and grey lag geese in spring, while other species e.g. warblers use reed beds as pre-migration feeding areas. Reed beds are used by numerous nesting birds in the spring and summer mating season, e.g. the bearded tit, reed warbler, bittern and the marsh harrier (Fuller, 1982; Hawke & José 1996).

Habitat structure and complexity

The leaves and stems of *Phragmites australis* provide substratum and refuge for several species, while the rhizome and root system stabilize the sediment, and transport of oxygen from the stems, including dead stems, to the roots oxygenates the sediment in the vicinity of the roots (the rhizophere) changing the local redox potential, sediment chemistry and oxygen levels. *Phragmites* reed beds are an important component of emergent vegetation communities, and may occur near the waters edge in ditches and estuaries or as landward part of the hydrosere above saltmarsh habitats. Therefore, the complexity of the habitat and its species composition will vary both within and between locations. Variation in salinity within the reed bed adds complexity and variation in dominance by invertebrates or fish of marine origin rather than invertebrates and fish of terrestrial or freshwater origin (see Arnold & Ormerod, 1997). The gross structure a British reed bed is given by Hawke & José, (1996; Figure 1). The finer structure of the habitat with respect to invertebrates is probably similar to other aquatic macrophyte habitats e.g. *Ruppia* spp. communities (see IMS.Rup) . The reed bed probably comprises the following components (adapted from Verhoeven & van Vierssen,1978; Verhoeven 1980a; van Vierssen & Verhoeven, 1983, and Hawke & José, 1996).

- *Phragmites australis* and other associated aquatic macrophytes or macroalgae (see Rodwell, 1995);
- mats of filamentous algae, e.g. *Cladophora* spp., and *Ulva* spp., that harbour high densities of invertebrates e.g. aquatic insects, chironomid larvae, amphipods, and copepods (Verhoeven & van Vierssen, 1978; Verhoeven 1980a; van Vierssen & Verhoeven, 1983);
- epiphytic species attached to the plants e.g. diatoms, filamentous diatoms, blue green algae, bacteria, and fungi (Haslam, 1972; Müller, 1999);
- temporary epiphytic species, e.g. aquatic insects;
- species depositing eggs on *Phragmites* and other macrophytes, e.g. insects, hydrobids, and some fish;
- species living in tubes attached to plants, e.g. the amphipod *Corophium volutator*;
- species creeping over plants and other hard substrata but not the sediment, e.g. amphipods, isopods, gastropods, and insect larvae;
- species creeping over plants and the sediment bottom, e.g. *Hydrobia* spp. and *Potamopyrgus* spp.;
- benthic infauna, e.g. oligochaetes, the polychaete *Hediste diversicolor*, the amphipod *Corophium volutator*, and chironomids (Arnold & Ormerod, 1997);
- mobile aquatic species occurring within the vegetation and the surrounding area, e.g. shrimps, crabs, mysids, gobies, and eels that probably vary with the tidal or emergence regime (Verhoeven & van Vierssen, 1978; Verhoeven 1980a; van Vierssen & Verhoeven, 1983);
- mobile species in the vegetation canopy, e.g. phytophagous insects, roosting birds, nesting birds and mammals (Fuller, 1982; Tscharntke, 1992; 1999; Hawke & José, 1996; Arnold & Ormerod, 1997), and
- an accumulated litter layer which provides nesting material for nesting species and shelter for other species e.g. hunting beetles and frogs.

In salt marsh habitats, *Phragmites australis* dominated communities represent the landward extreme of the hydrosere from pioneer salt marsh communities, through *Puccinellia maritima* communities (see LMU.NVC_SM13) to the higher or upper marsh. As the marsh becomes dryer, the *Phragmites* dominated communities give way to alder or willow carr (see Packham & Willis, 1997). In more brackish or freshwaters, *Phragmites* may lead the transition from submerged aquatic plants (see IMS.Rup and IMU.NVC_A12) to emergent vascular plants. The reader is directed to Rodwell (2000) for further information on saltmarsh communities and Rodwell (1995) for further information on aquatic plant communities.

Productivity

Primary productivity

Phragmites australis communities are amongst the most productive swamp communities (Rodwell, 1995). In Britain, mono-dominant stands of the common reed reach modal densities of over 100 shoots /m^2 but vary between 200 shorter shoots/m^2 or 30 shoots /m^2 (Rodwell, 1995). Above ground productivity was estimated to be as high as 100-150 tonnes/ha of standing crop in the Tay Estuary in a poor (cool) growing year in 1978 (Ingram *et al*., 1980), while other studies reported a standing crop of up to 1kg/m^2 and occasionally 2 kg/m^2 (Haslam, 1972; Rodwell, 1995). Rodewald-Rudescu (1974; cited in Ingram *et al*., 1980) suggested that only one third of total production was above ground, providing an estimated total productivity of reed biomass in the Tay Estuary in 1978 of about 300-450 tonnes/ha (Ingram *et al*., 1980). Haslam (1972) suggested that in fairly good to optimal stands total biomass may reach 10-40 tonnes/ha, although at least 36% and up to 96% of the biomass was below ground. Additional primary productivity derives from phytoplankton, periphyton, epiphytes and benthic microalgae, macroalgal mats within the bed as well as other vascular plants. Benthic microalgal productivity was reduced in *Phragmites* beds in comparison to salt marsh communities, and phytoplankton was of less importance in the brackish marshes of Delaware Bay (Wainwright *et al*., 2000).

Secondary productivity

Phragmites australis, macroalgae and microalgae supports consumers such as grazing gastropods and phytophagous insects, while its litter supports a wide variety of secondary consumers, including e.g. gammarid amphipods, isopods, chironomids, and bacteria. Wainwright *et al*., 2000 estimated that in Delaware Bay reed beds, *Phragmites australis* supported 73% of secondary productivity. *Phragmites* litter, resultant detritus, organic particulates and dissolved organic matter probably contribute to the wider aquatic food chain (Lee, 1990; Wainright *et al*., 2000). A summary of the net production and detritus dynamics in Mai Po Marshes, Hong Kong was given by Lee (1990).

The reed beds support a high biomass of terrestrial and aquatic invertebrates that provide secondary production further up the food chain (see ecological relationships). For example, Warren *et al* (2001) reported densities of ca 176/m^2 of *Orchestia grillus* and *Philoscia vittata* in tidal marshes of the Lower Connecticut river. Tscharntke (1999) reported insect densities, depending on emergence (dry vs. wet) and degree of damage by *Archanara geminipuncta*, of ca 140-269/m^2 for the gall inducing midge *Giraudiella inclusa*, ca 495-1618/m^2 for the gall inducing midge *Lasioptera hungarica*, and ca 6-13/m^2 for the twin-spotted wainscot *Archanara geminipuncta* in German reed beds. In Burry Inlet reed swamps, Arnold & Ormerod (1997) identified six communities of aquatic invertebrates that varied between ca 100 and 350 total invertebrate abundance (no of individuals collected).

Recruitment processes

Phragmites australis flowers in late August to early September, fruits ripen by November and seed are dispersed during winter and spring. Flowers are wind pollinated and each inflorescence may produce up to ca 1000 seeds. But fertility varies from 1-55&#37, depending on year, location, weather, and probably genetic variation between clones of *Phragmites*. Dispersal varies from 1-5 or 40% from same site in consecutive years (see Haslam 1972). The seed is plumed and dispersal is usually by wind, although birds nesting in the reed beds may also transport seed when collecting nesting material. Unshed seed may fall with the inflorescence only to be dispersed by water or man (Haslam, 1972).

Seed germination is variable and usually poor in the field, especially on organic soils (e.g. peat and within reed beds). Germination occurs over a wide range of temperatures, is slower at lower temperatures (ca 10-30 °C) and stopped by frost. The effect of water varies, some worker suggesting sowing at or below water level, other reporting germination in 1.5m of water and other no germination in 5 or 15cm of water and increased germination with drying. Germination also varies with salinity. In addition, seedlings are killed by frost, damaged by saline conditions, leave die underwater and may be stunted on organic soils, preferring mineral soils or muds with a flow of nutrient rich water (Haslam, 1972). Overall, sexual reproduction by seed is limited and seedlings are rarely observed in the field, except in new habitats devoid of other macrophytes (e.g. resulting form disturbance). However, propagation by seed is probably adequate to the long-lived clones of *Phragmites* (Haslam, 1972).

Vegetation reproduction by clonal spread of horizontal rhizomes is probably more important to the maintenance and expansion of established beds. Once established the *Phragmites* produces horizontal rhizomes that spread across the surface producing new vertical shoots and roots at each internode (Hawke & José, 1996). Hawke & José (1996) reported expansion rates of 1-10m per year, sometimes faster, depending on temperature and water depth. Amsberry *et al.* (2000) noted that underground rhizomes spread horizontally about 1-1.5m per year. Pieces of rhizome may be transported by water or man (but die at sea) and may act as an effective mode of dispersal. Cutting of rhizomes, stems and shoots are used to propagate reed beds and fragments of the common reed would probably root in the wild if they arrived on suitable substrata.

Other species

The microalgae and filamentous macroalgae found within the biotope are widespread and ubiquitous, producing numerous spores, and can colonize rapidly. Similarly, bryozoans such as *Conopeum seurati* probably produce numerous but short lived pelagic larvae, so that local recruitment from adjacent populations is probably rapid. For example, *Einhornia crustulenta* is probably adapted to rapid growth and reproduction (*r*-selected), capable of colonizing ephemeral habitats, but may also be long lived in ideal conditions (Hayward & Ryland, 1998). In settlement studies, *Einhornia crustulenta* (as *Electra crustulenta*) recruited to plates within 5 -6months of deployment (Sandrock *et al.*, 1991). Boström & Bonsdorff (2000) examined the colonization of artificial seagrass beds by invertebrates. They reported colonization by abundant nematodes, oligochaetes, chironomids, copepods, juvenile *Macoma baltica* and the polychaete *Pygospio elegans* within 33-43 days. Disturbance by strong winds after 43 days resulted in a marked increase in the abundance of species by day 57, except for *Pygospio elegans*. They noted that settlement of pelagic larvae was less important than bedload transport, resuspension and passive rafting of juveniles from the surrounding area in colonization of their artificial habitats. The above observation suggests that most aquatic macrobenthic species in reed beds may recruit rapidly.

Mobile species, such as the gammarids, small gastropods and mysids are probably able to recruit and colonize available habitats from the surrounding area. Hydrobid molluscs produce pelagic larvae capable of considerable dispersal and may also colonize new habitats by rafting. Coleoptera (beetles), Odonata (dragonflies) and Heteroptera (true-bugs), with adults capable of flight, will probably be able to colonize available habitats relatively quickly once established, although the ability to fly varies between species (van Vierssen & Verhoeven, 1983). For example, the aphid *Hyalopterus pruni* colonizes reed beds annually in summer, although it reaches its highest densities at the edges of reedbeds, before migrating to its main host cherry trees (*Prunus* sp.). The larvae of the twin-spotted wainscot *Archanara geminipuncta*damages thick shoots and induces thinner side shoots (Tscharntke, 1992). Several, species are dependant on the shoot damage or side shoots induced by the twin-spotted wainscot. For example, the gall forming midge *Lasioptera arundinis*, gall forming flies (*Lipara lucens* and *Lipara ruftitarsis*) benefit from the additional thin side shoots, while some species of fly (Chloropidae) feed on the droppings of the twin-spotted wainscot (Tscharntke, 1992, 1999). Therefore, their recruitment is dependant on the presence of the twin-spotted wainscot, which itself demonstrates a flush and crash life cycle every 3-4 years (Tscharntke, 1992).

The stickleback *Gasterosteus aculeatus* may be associated with reed beds. The males set up a territory and build nests, in which the female lays eggs that are subsequently fertilized and guarded by the males (Fishbase, 2000). The abundance of vegetation provided by the reed bed and its associated algal mats probably provides nesting material for the males and a refuge for developing juveniles. While associated with this biotope, sticklebacks are mobile species capable of colonizing the habitat from adjacent areas or the open sea. Similarly, amphibians, reptiles and birds are highly mobile and probably recruit to the habitat rapidly from the surrounding areas.

Time for community to reach maturity

Once established expansion of a reed bed may be relatively rapid. For example, at Hickling, Norfolk an area of derelict grazing marsh was bunded to allow colonization by the common reed, and a closed stand of reed formed over 50ha within 5 years. Colonization by associated mobile species is probably rapid. Cunha & Moreira (1995, Figure 9) noted that peak abundance of molluscs, leeches and insects in pondweed beds occurred in spring and summer, probably coincident with the peak of macrophyte biomass, while oligochaete and crustacean abundance peaked during late autumn and winter probably coincident with decomposition of senescent macrophytes. Their observation suggest that the species richness and density of aquatic invertebrates fluctuates seasonally with macrophyte abundance or decomposition, suggesting that different invertebrate groups can colonize the pondweed beds readily, depending on season. Similarly, terrestrial insects can potentially colonize the reed bed rapidly on a seasonal or annual basis. Tscharnkte (1992) noted that the species richness of reed bed habitat depended on the age, stability and size. For example, a 2ha habitat could support 180,000 twin-spotted wainscot during outbreaks but could not persist, being dependent on rapid recruitment from neighbouring populations. The larvae of the reed leopard moth spends two years within the stems of *Phragmites*, while the twin-spotted wainscot overwinters as eggs on stems and pupates within thick stems of reed, both therefore, requiring established and stable beds. Small stands of stressed plants are likely to be better habitats for gall forming midges, gall forming flies, and the aphid *Hyalopterus pruni*. Bird species vary in their needs but conservation (i.e. viable populations) of most of the bird species found in reed beds requires stands of at least 2ha. For example, the reed warbler breeds in reed patches >1600m^2, the marsh warbler and reed bunting breed along edges of stands >9000m^2, while the great reed warbler (*Acrocephalus arundinis*) prefers watersides of reed belts >21,000m^2 (Tscharntke, 1992). The litter layer is often used by bearded tits which prefer to nest amongst dead stem. Nesting reed warblers were reported to occupy cut areas rapidly, and after one years growth of reed nests were recorded at densities of 20/ha increasing to 35-40/ha within 2-3 years. Therefore, the development of the terrestrial community is dependant on the size of the reed bed and hence the time taken for it to develop. The species richness of the aquatic invertebrate community and decomposers is probably also dependant on the build up of litter within the bed.

Additional information

None entered.

Preferences & Distribution

Habitat preferences

Depth Range	
Water clarity preferences	
Limiting Nutrients	Nitrogen (nitrates), Phosphorus (phosphates)
Salinity preferences	
Physiographic preferences	
Biological zone preferences	
Substratum/habitat preferences	
Tidal strength preferences	
Wave exposure preferences	
Other preferences	Wet or periodically waterlogged habitats

Additional Information

Marine records of this biotope are restricted to Scottish saline lagoons (JNCC, 1999) but the equivalent NVC S4 community is widespread in lowland Britain and has a scattered distribution in estuaries and inlets and coastal lagoons around the British Isles (Rodwell, 1995). NVC S4 occurs in a variety of permanently wet or periodically waterlogged habitats, with different substrata and trophic states. Reed stands are common in open-water transitions around lakes, estuaries, flood-plain mires, along dykes, canals and sluggish lowland rivers, peat cuttings, salt marshes and saline lagoons (Rodwell, 1995).

Habitat preferences

- *Phragmites* survives in a variety of water regimes with water-tables varying between 2m above the substratum to 1m below. Optimal performance occurs with water levels between 50cm above the substratum to 20cm below, and flooding for at least several months of the year. Healthy growth is favoured by a regular water regime, and *Phragmites* is uncommon in areas subject to erratic variation in water level (Haslam, 1978; Rodwell, 1995).
- *Phragmites* tolerates water-logging and reducing conditions (low oxygen) as long as the rhizomes remain aerated through dead aerial stems (Rodwell, 1995).
- The depth of the bed is limited by photosynthetic ability since the leaves of *Phragmites* die underwater, and about one third or more of the shoot needs to be above water.
- In tidal waters in the Netherlands, *Phragmites* grows between 1.5m below to 0.25m above mean high water and optimally between 1m below and 0m above (Haslam, 1972).
- Nutrients (N and P) are limiting, and *Phragmites* grows best in eutrophic conditions (Rodwell, 1995).
- Where nutrients are in adequate supply, *Phragmites* shows few substratum preferences, growing on mineral or organic soils, but seedlings show a preference for mineral soils, while the common reed is a good peat forming species and, hence, often associated with organic soils. The common reed forms only a thin cover on nutrient poor silts or acid peats.
- *Phragmites australis* is characteristic of negligible or slow water flow and IMU.NVC_S4 was recorded from saline lagoons with very weak tidal streams in extremely to ultra wave sheltered conditions, although it was intolerant of fast flow or flood, presumably due to erosion of the substratum (Haslam, 1978; Connor *et al*., 1997a).
- *Phragmites* tolerates salinities between 2 -12 g/l, but up to 22 g/l in Poole Harbour,

although bud formation is reduced at high salinities (Rodwell, 1995). Hellings & Gallagher (1992) reported that shoot density, height, biomass, underground reserves and rhizome carbohydrates decreased with increasing salinity, from 0 to 15 and 30 g/l. However, stands of *Phragmites* have been reported to grow at salinities of up to 65g/l (Hellings & Gallagher, 1992). Amsberry *et al.* (2000) reported that colonization of new habitats by *Phragmites* was restricted by physical factors including salinity but that the expanding reed bed could colonize low salt marsh habitats and hence higher salinities by clonal, vegetative growth.
- *Phragmites* occurs from tropical areas to above 70° N (Haslam, 1972).
- *Phragmites* becomes more sterile towards its northern European limit, and shoots cannot grow in cold weather and are killed by severe frost. In Britain it must complete its annual growth between April and September, while its growing season is longer in Malta. Warmer temperatures stimulate growth (Haslam, 1972; Rodwell, 1995).

For further details see Haslam (1972, 1978) and Rodwell (1995). Detailed accounts of the physical and chemical tolerances of *Phragmites australis* in fresh waters and sediments are given by Haslam (1978) and an overview of factors affecting growth is provided by Boar (1992). The habitat requirements for the associated bird species are discussed by Tyler (1992).

Species composition

Species found especially in this biotope

- *Acrocephalus palundicola*
- *Acrocephalus schoenobaenus*
- *Acrocephalus scirpceus*
- *Agonium thoreyi*
- *Archanara geminipunctata*
- *Arenostola phragmitidis*
- *Atriplex prostrata*
- *Botaurus stellari*
- *Carex rostrata*
- *Cettia cetti*
- *Chara aspera*
- *Circus aeruginosus*
- *Circus cyaneus*
- *Dromius longiceps*
- *Equisetum fluiatile*
- *Galium palustre*
- *Gasterosteus aculeatus*
- *Giraudiella inclusa*
- *Grus grus*
- *Hyalopterus pruni*
- *Lamprothamnium papulosum*
- *Lasioptera arundinis*
- *Lipara lucens*
- *Lipara ruftitarsis*
- *Locustella luscinioides*
- *Macroplea mutica*
- *Menyanthes trifoliata*

- *Micromys minutus*
- *Panurus biamicus*
- *Photedes brevilinea*
- *Phragmataecia castaneae*
- *Phragmites australis*
- *Potamopyrgus jenkinsi*
- *Puccinellia maritima*
- *Rhizedra lutosa*

Rare or scarce species associated with this biotope

- *Acrocephalus palundicola*
- *Botaurus stellari*
- *Cettia cetti*
- *Circus aeruginosus*
- *Dromius longiceps*
- *Grus grus*
- *Lamprothamnium papulosum*
- *Locustella luscinioides*
- *Panurus biamicus*
- *Photedes brevilinea*
- *Phragmataecia castaneae*

Additional information

The MNCR recorded only 20 species in a few records of the biotope but the biotope has been more extensively studied as the NVC S4 community. Rodwell (1995) described 4 sub-communities and 3 variants, including up to ca 40 species of vascular plants. Hawke & José (1996) reported that at least 700 species of invertebrates had been found associated with UK reed beds, of which 64 insects species were dependant on reed to some extent and 40 were entirely dependant, including 11 species of Lepidoptera whose larvae feed on reed (Fojt & Foster, 1992; Hawke & José, 1996). Arnold & Ormerod (1997) recorded 56 species of aquatic invertebrates in *Phragmites* reed swamps, most belonging to 1-6 families of Coleoptera, the Isopoda, Amphipoda or Gastropoda, with abundant Diptera (9 families). The species richness varies with salinity, habitat fragmentation (reed bed size), reed density, the abundant of litter, damage by the twin-spotted wainscot emergence regime, and management regime (Tscharnkte, 1992, 1999; Fojt & Foster, 1992; Hawke & José, 1996; Ditlhogo *et al.*, 1992; Cowie *et al.*, 1992; Arnold & Ormerod, 1997; Fell *et al.*, 1997). *Phragmites* reed swamps are transitional communities between brackish water, saltmarsh and inland plant communities. Therefore, they are potentially species rich habitats inhabited by representatives of saline, brackish water and terrestrial macroinvertebrates, fish, amphibians, reptiles, birds and mammals. Lists of associated species are given by Haslam, 1972; Tscharnkte, 1992, 1999; Fojt & Foster, 1992; Hawke & José, 1996; Ditlhogo *et al.*, 1992; Cowie *et al.*, 1992; Arnold & Ormerod, 1997; Fell *et al.*, 1997; and Müller, 1999). Reed beds support several species of conservation importance such as nationally or internationally rare moths and birds (see importance) (Fojt & Foster, 1992; Hawke & José, 1996).

Sensitivity review

Explanation

Phragmites australis stabilizes the sediment, develops an organic sediment, provides a litter layer, and supports numerous species directly and indirectly, and provides primary productivity to the wider aquatic ecosystem. Amsberry *et al.* (2000) regarded the common reed as an 'ecosystem engineer'. Therefore, *Phragmites australis* has been chosen as the key structural species within the biotope. Grazers are probably important species in the food chain converting *Phragmites australis* and algal primary production to secondary production, directly available to their predators and to the wider community via the detrital food chain. In addition, their grazing activities probably control the growth of epiphytes that would otherwise shade or compete with the macrophytes. *Hydrobia ulvae* is included to represent gastropod grazers, while reference was made to *Gammarus salinus* and *Gammarus insensibilis* (the lagoon sand shrimp) to represent gammarid amphipod grazers. The mysid *Neomysis integer* has been used to represent the sensitivity of mysid species. Similarly, reference was made to *Pomatoschistus minutus* to represent the sensitivities gobies and other small fish.

Species indicative of sensitivity

Community Importance	Species name	Common Name
Important functional	*Gammarus insensibilis*	Lagoon sand shrimp
Important functional	*Gammarus salinus*	A gammarid shrimp
Important functional	*Hydrobia ulvae*	Laver spire shell
Important other	*Neomysis integer*	Opossum shrimp
Key structural	*Phragmites australis*	Common reed

Physical Pressures

	Intolerance	Recoverability	Sensitivity	Richness	Confidence
Substratum Loss	High	Moderate	Moderate	Major decline	Low

Removal of the substratum due to dredging or other activity would result in loss of the reed bed, including aerial stems and rhizomes, together with its associated community. Therefore an intolerance of high has been recorded. Recovery will depend on colonization of the habitat by seed or plant fragments and may be protracted (see recoverability below). Therefore a recoverability of moderate has been recorded.

	Intolerance	Recoverability	Sensitivity	Richness	Confidence
Smothering	Low	Immediate	Not sensitive	Minor decline	Low

Little information was found. Haslam (1978) noted that *Phragmites australis* maintains the same root (rhizome) level as sediment builds up. But reed beds usually accumulate sediment, organic material and litter, through which shoots continue to grow. Smothering with 5cm of sediment (see benchmark) may impair growth if it occurred in spring before or during growth of new shoots. In late spring or summer aerial shoots are considerably higher than 5cm an would be little affected. However, *Phragmites* was reported to be able to grow through ca 10cm of tarmac, albeit as thin and small shoots (Haslam, 1973 cited in Baker *et al.*, 1989).

Benthic infauna are likely to be little affected. Amphipods, isopods and aquatic insects may be adversely affected if they cannot burrow up through the smothering material or their food source (e.g. benthic microalgae or macroalgae) are destroyed. However, little damage is likely to occur to the bed due to smothering by 5cm of sediment for a month (see benchmark) as any grazers lost in the bed will probably be rapidly replaced from the surrounding area. Therefore, an intolerance of low has been recorded. Recovery would be immediate.

Increase in suspended sediment	Tolerant	Not relevant	Not relevant	No change	Not relevant

Phragmites australis occurs in low water flow habitats, often with high levels of suspended sediment, e.g. estuaries. In addition, its stems slow water flow further, resulting in increased sediment deposition, and it builds up and binds organic sediment due to accumulation of litter, dead rhizomes and roots. The habitats in which the biotope occurs are depositional environments, so that most aquatic organisms inhabiting the environment are probably also tolerant of sedimentation and suspended sediment. An increase in suspended sediment at the benchmark level is unlikely to adversely affect the reed bed or its associated species. However, in the long term (many years) increased sedimentation will allow the reed bed to colonize deeper water, although it may be out-competed at its inland limit in the absence of management (see emergence). Therefore not sensitive has been recorded.

Decrease in suspended sediment	Tolerant		Not sensitive*	Rise	Low

Phragmites australis builds up and binds organic sediment due to accumulation of litter, dead rhizomes and roots. A decrease in suspended sediment in the long term could potentially increase the erosion rate. But at the benchmark level (one month) a change in suspended sediment is unlikely to have an adverse effect. Therefore, not sensitive has been recorded.

Dessication	Tolerant	Not relevant	Not relevant	No change	Low

Phragmites australis occurs in a variety of water regimes with water tables between 2m above to 1m below the substratum surface. The *Phragmites* dominated community occurs from permanently deep to shallow water, and from summer-dry and winter flooded areas. Therefore, *Phragmites* is probably tolerant of desiccation at the benchmark level. Mobile species such as gammarids, mysids and fish will probably avoid drying conditions and move to deeper water, while hydrobids are probably tolerant of desiccation, e.g. *Hydrobia ulvae* can survive emersed in sediment at the high strandline for over a week. But, bryozoans are restricted to damp habitats on the shore, so that colonies on emergent plants are likely to be adversely affected. The litter and peaty organic substratum generated by *Phragmites* probably holds water and provides a damp microclimate for aquatic invertebrates such as isopods, amphipods and benthic infauna in tidal sites. Therefore, the reed bed and its associated community is probably not sensitive to increases in desiccation at the benchmark level. However, in the long term, a reduction in the water table, or an accumulation of sediment and litter, may reduce the *Phragmites* density and allow other species to colonize the reed bed, e.g. as in the *Galium palustre* sub-community (Rodwell, 1995).

Increase in emergence regime	Intermediate	High	Low	Rise	Low

Phragmites australis occurs in a variety of water regimes with water tables between 2m above to 1m below the substratum surface, although optimum performance occur in water levels ranges between 50cm above to 20cm below the substratum surface (Rodwell, 1995). As sediment and litter accumulate, the water table effectively falls deeper into the sediment, giving rise to a landward succession of increasingly drier habitats. Succession may be complex (see Rodwell, 1995). However, a reduction in water level usually results in the landward replacement of the *Phragmites* communities with the *Galium* sub-community (Rodwell, 1995) or the *Atriplex* sub-community in saline sites, usually interspersed with other saltmarsh communities (see Rodwell, 1995, 2000). As the soil becomes dryer the reed bed may give way to fen, swamp or alder/willow carr (Rodwell, 1995). Therefore, with increasing emergence and hence lowering of the water table, the monodominant stands of the *Phragmites* sub-community give way to more species rich sub-communities.

The diversity of soil invertebrates is likely to increase to the detriment of aquatic invertebrates. Mobile species (e.g. fish, gammarids and mysids) will probably avoid the factor and filamentous green algae (e.g. *Ulva* spp.) are probably tolerant of emersion, while emersed bryozoans may be adversely affected due to the increased desiccation risk, potentially reducing aquatic species richness.

Excessive drainage and water abstraction have been implicated in the decline of reed beds in the UK (Anon, 1995). But the succession described above is likely to be a long term effect of a marked reduction in water level. *Phragmites australis* tolerates a wide range of water levels and a change in emergence at the benchmark level is unlikely to have a marked effect on the reed bed over a period of year, although competition form other species is likely to be increased in that period. Nevertheless, reed beds are intolerant of larger or prolonged changes in water level, as are, therefore those organisms dependent on dense stands of reed such as the bittern and reed bunting. Therefore, an intolerance of intermediate has been recorded to represent the known importance of the emergence regime in the longevity and maintenance of reed beds. Recoverability is likely to be high (see additional information below).

Decrease in emergence regime	Intermediate	High	Low	No change	Low

Phragmites australis occurs in a variety of water regimes with water tables between 2m above to 1m below the substratum surface, although optimum performance occur in water levels ranges between 50cm above to 20cm below the substratum surface (Rodwell, 1995). In tidal waters in the Netherlands, *Phragmites* grows between 1.5m below to 0.25m above mean high water (MHW) and optimally between 1m below and 0m above MHW (Haslam, 1972). The maximum depth that *Phragmites* can colonize is dependant on their ability to put a photosynthetic canopy above water. The leaves of *Phragmites* die underwater and greater than about one third of the aerial shoot must be above water for growth (Rodwell, 1995). But maximum depth also varies with trophic status, so that in oligotrophic Scottish lakes it may be only 0.75m but increases in eutrophic lakes or with increasing temperature. *Phragmites* can survive the low oxygen conditions associated with water logged soils as long as dead aerial stems remain to supply air to the rhizomes (Rodwell, 1995). Where dead aerial stems are cut or removed by wave action, or the stubble flooded too deeply bud growth in late summer and spring is reduced (Rodwell, 1995). Hellings & Gallagher (1992) noted that mixture of cutting and flooding with brackish water resulted in death of experimental stands of reed.

Therefore, increased immersion is likely to limit the seaward extent of *Phragmites*, perhaps favouring more typical saltmarsh communities (e.g. A5.542) and a more marine aquatic fauna and macroalgae. However, the inland extent of the reed bed may increase in the long term. Fell *et al.* (1998) and Warren *et al.* (2001) noted little different in macroinvertebrate or fish populations between saltmarsh habitats and saltmarsh invaded by *Phragmites* in Connecticut, USA, so species richness and community structure may not be affected. Overall, an intolerance of intermediate has been recorded to represent the potential loss of the seaward extent of the biotope, although recovery is likely to be rapid (see additional information below).

Increase in water flow rate	Intermediate	High	Low	Decline	Low

Phragmites australis is characteristic of negligible or slow water flow and IMU.NVC_S4 was recorded from saline lagoons with very weak tidal streams in extremely to ultra wave sheltered conditions. But it was reported to be intolerant of fast flow or flood, presumably due to erosion of the substratum (Haslam, 1978; Connor *et al.*, 1997a). *Phragmites* is deep rooted with rhizomes between 40-100cm below the surface, sometimes up to 1.5-2m deep, and therefore difficult to erode and strongly anchored in the substratum (Haslam, 1978). But Haslam (1978) reported that *Phragmites* was intolerant of water movement due to waves or currents. While it could withstand slight scour it was damaged by moderate exposure and absent from severe exposure to wave action or water flow in rivers and lakes (Haslam, 1978).

The crustacean fauna is found in strong water flow and will be probably unaffected by increased water flow directly. However, loss of vegetation, and loosely attached filamentous algal mats will reduce their food supply.

Overall, an increase in water flow from very weak to moderately strong (see benchmark) is likely to remove the litter layer, increase scour and erode the substratum, resulting in loss of plants at the seaward edge, although some rhizomes will probably remain. Over a period of a year, the reed bed will probably be damaged and reduced in extent. A reduction in the extent of the reed bed and hence the available habitat may have adverse effects on the associated terrestrial fauna, e.g. insects and birds (see Tscharntke, 1992). Therefore, an intolerance of intermediate has been recorded. Once flow returns to prior conditions and sediment builds up, recover will probably be rapid (see additional information below).

Decrease in water flow rate			Not sensitive*	Not relevant	

Phragmites australis is characteristic of negligible or slow water flow and IMU.NVC_S4 was recorded from saline lagoons with very weak tidal streams in extremely to ultra wave sheltered conditions. A further reduction to negligible water flow is unlikely to have any adverse effects.

Increase in temperature	Tolerant*	Not relevant	Not sensitive*	No change	Low

Phragmites australis occurs from north of 70° N to the tropics. Growth, fertility and the length of the growing season increase with increasing temperatures (Haslam, 1972). For example, reeds may grow up to 4m in Malta even with a water level ca. 6m below ground, up to 6m tall in the Danube Delta and up to 6.7m in Uganda (Haslam, 1972). However, Haslam (19720 noted that the increase in height was controlled by several factors rather than just temperature.

The majority of the characterizing species have broad temperatures tolerances or are widely distributed to the north or south of Britain and Ireland, and unlikely to be affected by changes in temperature at the benchmark level. But an acute increase in temperature may adversely affect spring populations of *Neomysis integer* (see species review).

Overall, an increase in temperature at the benchmark level may benefit the growth, expansion rate and fertility of the reed bed, potentially to the advantage of the associated species. Therefore, not sensitive* has been recorded.

Decrease in temperature	Intermediate	High	Low	Minor decline	Low

Phragmites australis occurs from north of 70° N to the tropics but becomes sterile towards its northern limit (Haslam, 1972). Shoots cannot grow in cold weather and are killed by severe frost. Spring frost can markedly affect growth and shoot density. Moderate spring frost may kill the dominant dormant buds, so that subsequent shoots are thinner and shorter. Haslam (1972) noted that light spring frost can cause an increase in shoot density, and standing crop. Buds lost in spring may be replaced, whereas replacement shoots that emerge later cannot. Very heavy or repeated frosts can kill all emergent shoots, preventing their replacement in that season, causing marked short-term variation in reed beds that can take several seasons to recover. A build up of litter provides some protection against frost, so that reed beds exhibit variation in their susceptibility to frost (Haslam, 1972; van der Toorn & Mook, 1982; Rodwell, 1995).

The majority of the characterizing species have broad temperatures tolerances or are widely distributed to the north or south of Britain and Ireland, and unlikely to be affected by changes in temperature at the benchmark level.

Overall, a long term decrease in air temperature is likely to increase the risk of frosts. Severe frosts in spring could potentially result in loss of a years growth of reed, with resultant reduction in primary productivity within the biotope and the wider ecosystem, loss of food plants to insects and hence bird species. Therefore, an intolerance of intermediate has been recorded. Recovery will probably be rapid (see additional information below).

Increase in turbidity	Tolerant	Not relevant	Not relevant	Minor decline	Not relevant

Phragmites australis forms aerial stems up to 4m in height with leaves above water level. It is an effective competitor for light, excluding many other species in monodominant stands. Haslam (1978) suggested that the common reed was relatively tolerant of shading. Therefore, *Phragmites* itself is unlikely to be adversely affected by an increase in water turbidity. Increased turbidity will probably reduce the growth of epiphytic or filamentous green algae and charophytes (e.g. *Lamprothamnium papulosum)* but most invertebrates are unlikely to be affected directly, although loss of algal productivity will reduce the food supply for grazers and ultimately decomposers and deposit feeders. On balance, not sensitive has been recorded.

Decrease in turbidity	Tolerant		Not sensitive*	Rise	

A decrease in turbidity (or shading) may allow submergent or emergent macrophytes (e.g. the charophyte *Lamprothamnium papulosum*)) to increase in abundance. However, the dominance of *Phragmites* probably has a greater effect on the availability of light within the reed bed. The growth of algal epiphytes, periphyton and benthic microalgae may be increased by increased light availability, resulting in a minor increase in primary productivity, when compared to *Phragmites*. Overall, a decrease in turbidity is unlikely to have any adverse effects.

Increase in wave exposure	Intermediate	High	Low	Minor decline	Low

Phragmites dominated communities and saltmarsh communities occur in wave sheltered environments. Although, saltmarsh plant communities and reed beds bind sediment and attenuate wave energy, an increase from extremely wave sheltered to 'sheltered' may adversely affect the habitat. Haslam (1978) reported that *Phragmites* was intolerant of water movement due to waves or currents. While it could withstand slight scour it was damaged by moderate exposure and absent from severe exposure to wave action or water flow in rivers and lakes, and wave action may result in the formation of mats of rotting reed (Haslam, 1978).

The majority of the associated aquatic invertebrate species are probably adapted to wave sheltered conditions, or fine sediments associated with wave sheltered conditions. Mobile species such as mysids, gobies and sticklebacks will probably move to deeper water to avoid wave turbulence. More sedentary gammarids or hydroids may be washed away, while the benthic infauna may be changed due to changes in the substrata from fine to coarser sediment, and a proportion of the epifauna (including insects) and epiflora will be lost on removed vegetation. Increased wave action may result in loss of the litter layer and hence loss of nesting material or nesting sites for reptiles (e.g. the grass snake) and the bittern.

Overall, an increase in wave action at the benchmark level may result in loss of a proportion of the biotope at its seaward limit, together with its associated community. Therefore, an intolerance of intermediate has been recorded. Recovery will probably be rapid (see additional information below).

Decrease in wave exposure			Not sensitive*	Not relevant	

Phragmites australis is characteristic of negligible or slow water flow and IMU.NVC_S4 was recorded from saline lagoons in extremely to ultra wave sheltered conditions. A further reduction in wave exposure is unlikely.

Noise	Intermediate	Very high	Low	Minor decline	Very low

The vascular and non-vascular plants and invertebrate species within the biotope are unlikely to be adversely affected by noise. But wildfowl are intolerant of disturbance from noise from e.g. shooting (Madsen, 1988) and from coastal recreation, industry and engineering works. For example, Percival & Evans (1997) reported that wigeon were very intolerant of human disturbance and, where wildfowling was popular, wigeon avoided *Zostera noltii* beds at the top of the shore. Birds are likely to be most intolerant of disturbance during the mating season, where noise may interfere with mating calls, or interrupt nesting or food gathering for their young. But the intolerance to noise and visual presence probably varies with species. For example brent geese, redshank, bar-tailed godwit and curlew are more 'nervous' than oyster catcher, turnstone and dunlin. Turnstones will often tolerate one person within 5-10m but one person on a tidal flat can cause birds to stop feeding or fly off affecting c. 5 ha for gulls, c.13ha for dunlin, and up to 50 ha for curlew (Smit & Visser 1993). Goss-Custard & Verboven (1993) report that 20 evenly spaced people could prevent curlew feeding over 1000 ha of estuary. No information concerning the effects of noise of the bittern or reed bunting was found. However, an increase in noise at the benchmark level could potentially affect feeding and reproduction in important bird species, possibly driving nesting birds away from the site, and an intolerance of intermediate has been recorded albeit at very low confidence. Recovery of birds population may be immediate for some species, while shy species may find more isolated sites and take longer to return.

Visual Presence	Intermediate	Very high	Low	Minor decline	Very low

The vascular and non-vascular plants and invertebrate species within the biotope are unlikely to be adversely affected by noise but birds are likely to be more intolerant. Disturbance is species dependant, some species habituating to visual disturbance while other become more nervous. For example, brent geese, redshank, bar-tailed godwit and curlew are more 'nervous' than oyster catcher, turnstone and dunlin. Turnstones will often tolerate one person within 5-10m. However, one person on a tidal flat can cause birds to stop feeding or fly off affecting c. 5 ha for gulls, c.13ha for dunlin, and up to 50 ha for curlew (Smit & Visser 1993). Goss-Custard & Verboven (1993) report that 20 evenly spaced people could prevent curlew feeding over 1000 ha of estuary. Disturbance causes birds to fly away, increasing energy demand, or cause them to move to alternative sites. Least human disturbance is likely in winter, however during breeding periods for some species and moulting periods of northerly breeding species in late summer and early autumn most recreational activity takes place, potentially reducing reproductive ability. Therefore an intolerance of intermediate has been recorded for birds in general. Recovery of birds population may be immediate for some species, while shy species may find more isolated sites and take longer to return.

Abrasion & physical disturbance	Intermediate	High	Low	Decline	Low

The aerial stems of *Phragmites australis* are cut as part of management, either as a crop or to prevent succession. Cutting and burning may increase plant diversity, and winter cutting of dead stems also increases the next season's crop (Haslam, 1972; Cowie *et al.*, 1992; Rodwell, 1995). Cutting in spring or summer removes causes a reduction of the crop due to loss of irreplaceable shoots, the effects possibly lasting several seasons (Haslam, 1972; Rodwell, 1995). Loss of the winter material and litter may expose the reed to frost damage (see temperature).

Light grazing by wildfowl, livestock, and deer may be tolerated resulting in a denser bed of reed more suitable for bittern (Rodwell, 1995). Heavy grazing may be more damaging. Grazing removes young shoots while the resultant trampling damages upper rhizomes and decreases bud density (Haslam, 1972). Grazing by Canada and grey lag geese was reported to have contributed to the decline of reed beds in Broadland, although non-native coypu (now extinct) probably had a greater impact (Rodwell, 1995). Amsberry *et al.* (2000) suggested that physical disturbance of salt marsh plant communities may allow *Phragmites* to colonize low marsh habitats

Cowie *et al.* (1992) and Dithlogo *et al.* (1992) reported that their management regimes (cutting, burning and unmanaged) had little effect on the species richness, species diversity and distribution of macroinvertebrates, including soil invertebrates.

Overall, physical disturbance due to anchorage will probably damage a few stems and rhizomes but otherwise have little effect on the reed bed.. But the combined effects of grazing and drainage has been implicated in the decline reed beds (Rodwell, 1995). In addition, Wade (1999) reported that the mooring developments resulted in significant local damage of reed beds in Llangorse lake, south Wales, although no effect of water-based recreation could be demonstrated. Therefore, *Phragmites* reed beds are probably sensitive to the effects of grazing, trampling, and moorings and an overall intolerance of intermediate has been recorded. Recoverability is probably high (see additional information).

Displacement	High	Moderate	Moderate	Major decline	Low

Phragmites australis would probably be severely damaged and fragmented by displacement, resulting in loss of filamentous algae, epiphytes, epifauna and the associated fauna. The mobile invertebrates, gammarids, mysids, fish and birds will probably be unharmed and migrate to adjacent areas. However, the community would probably be lost and a sensitivity of high has been recorded. Recoverability is probably moderate, although *Phragmites* is probably able to root from fragments of rhizome and stem, which may aid recovery (see additional information below).

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Richness	Confidence
Synthetic compound contamination	Intermediate	High	Low	Major decline	Low

Little information was found, however, herbicides are used to control or remove *Phragmites* beds, especially where beds may block water courses or it is considered an invasive species (e.g. the USA). For example, Hawke & José (1996) suggest that herbicides are an effect method for eliminating reed from areas to maintain or create open water. Therefore, it is likely that reed beds are intolerant of herbicide contamination, e.g. from agricultural runoff, especially in isolated areas where contaminants may accumulate such as lakes and lagoons. Pesticide contamination will by definition kill terrestrial insects, aquatic invertebrates, especially crustaceans, and may affect the reproductive success of bird species. Therefore, an intolerance of intermediate has been recorded. Recoverability of the reed and associated invertebrates is probably high, although some bird species may take longer to colonize the habitat.

Heavy metal contamination	Intermediate	High	Low	Decline	Low

Haslam (1978) suggested that macrophytes were little affected by heavy metals, since a countrywide survey had not been able to detect any correlation between plant distributions and heavy metal concentrations of Cr, Co, Cu, Fe, Pb, Mn, Ni, Sn and Zn. Windham *et al.* (2001) reported that *Phragmites australis* sequestered Pb (and by inference other heavy metals) into its rhizome system, reducing the availability of Pb to the wider ecosystem. But growth of *Phragmites* in sediment containing 68 µg/g Pb resulted in a 40-70% decrease in biomass (Windham *et al.*, 2001).

Cole *et al.* (1999) suggested that Pb, Zn, Ni and As were very toxic to algae, while Cd was very toxic to Crustacea (amphipods, isopods, shrimp, mysids and crabs), and Hg, Cd, Pb, Cr, Zn, Cu, Ni, and As were very toxic to fish. Gobies were reported to be particularly intolerant of Hg (see *Pomatoschistus minutus*). Bryan (1984) reported sublethal effects of heavy metals in crustaceans at low (ppb) levels.

Bryan (1984) suggested that polychaetes are fairly resistant to heavy metals, based on the species studied. Short term toxicity in polychaetes was highest to Hg, Cu and Ag, declined with Al, Cr, Zn and Pb whereas Cd, Ni, Co and Se were the least toxic. He also suggested that gastropods were relatively tolerant of heavy metal pollution.

The intolerance of crustaceans to heavy metal contaminants suggests that amphipod and isopod grazers would be lost, allowing rapid growth of epiphytes, and reduced turnover of the detrital food chain. Overall, in the absence of other evidence, the *Phragmites* beds would probably survive, with reduced productivity but several members of the community may be lost (e.g. fish and crustaceans) resulting in a reduced species richness. Therefore, an intolerance of intermediate has been recorded. Heavy metals are persistent and remain in the sediments for some time after their source is removed, so that recovery will probably be delayed. But once heavy metals return to prior conditions recovery would probably be rapid.

Hydrocarbon contamination	Intermediate	High	Low	Major decline	Moderate

Phragmites australis was regarded as relatively tolerant of oil pollution by Baker *et al.* (1989). Their evidence can be summarized as follows:

- most seaward reed stems were coated in oil after the *Sivand* oil spill in Humberside in September 1983 but no adverse effects were seen on shoots in 1984;
- in experiments, *Phragmites australis* survived 10 successive oiling with Forties crude

or heavy fuel oil at Slapton Ley;
- in water-logged substrata, growth of *Phragmites* was stunted by hydrocarbon concentrations of 57% but growth was good at 20% and near control levels at 3%, and
- In Crymlyn Bog, *Phragmites* grew well at up to 1500ppm hydrocarbons in the substratum although the shortest reeds were encountered where the substratum reached 7000ppm hydrocarbons.

Baker *et al.* (1989) reported that oil on the substratum surface may weather to a crust, which could potentially inhibit plant growth but noted that *Phragmites* was reported to be able to grow through ca 10cm of tarmac, albeit as thin and small shoots (Haslam, 1973 cited in Baker *et al.*, 1989).

Suchanek (1993) noted that gastropods, amphipods, infaunal polychaetes and bivalves were particularly sensitive to oil spills. For example substantial kills of *Nereis*, *Cerastoderma*, *Macoma*, *Arenicola* and *Hydrobia* were reported after the *Sivand* oil spill in the Humber (Hailey, 1995). Single oil spills were reported to cause a 25-50% reduction in abundance of *Arenicola marina* (Levell, 1976). The toxicity of oil and petrochemicals to fish ranges from moderate to high (Cole *et al.*, 1999). The water soluble fraction of oils was shown to cause mortality in sand gobies and fish, especially their larvae, are thought to be intolerant of polyaromatic hydrocarbons (PAHs) (see *Pomatoschistus minutus*). PAHs are significantly more toxic when exposed to sunlight (Ankley *et al.*, 1997) , and may have a greater effect in clear shallow waters inhabited by pondweed communities.

While *Phragmites* may be relatively tolerant of oil spills, the associated aquatic invertebrate and fish fauna, and probably the terrestrial invertebrate fauna are likely to be adversely affected. The effects of bird oiling is well known. Therefore, an intolerance of intermediate has been recorded to represent the presence of sensitive species within the habitat. Recovery is likely to be rapid once the site regains its prior condition, although some bids species may take longer to recolonize the habitat.

Radionuclide contamination		Not relevant		Insufficient information	Not relevant

No information found.

Changes in nutrient levels	Tolerant*	Not relevant	Not sensitive*	Rise	Low

Nitrogen and phosphorus are limiting, and nutrient deficiency limits bud density, development and subsequent aerial growth (Rodwell, 1995). *Phragmites* is characteristic of eutrophic conditions (Haslam, 1995). In oligotrophic conditions, *Phragmites* may be out-competed by other emergent macrophytes and swamp species, or may be represented NVC S4 sub-communities e.g. the *Menyanthes* sub-community S4c. Eutrophic conditions favour monodominant stands of *Phragmites*, although with increasing eutrophication the reed beds may give way to various kinds of *Phragmites-Urtica* fen (NVC S26), possibly including nitrophilous tall herbs (Rodwell, 1995). Amsberry *et al.* (2000) suggested that increased nutrients favoured expansion and colonization by *Phragmites*, and Bertness *et al.* (2002) suggested that shoreline development, removal of the woodland buffer between terrestrial and salt marsh communities and eutrophication was precipitating the invasion of salt marsh habitats by *Phragmites* in the New England, USA.

Eutrophication and the resultant increase in turbidity and phytoplankton may result in loss of submergent macrophytes. For example, it was suggested that the nationally rare foxtail stonewort *Lamprothamnium papulosum* was intolerant of nutrient enrichment being absent from water with >20 µg/l P as phosphate and preferring nutrient poor sites (Bamber *et al.*, 2001). Therefore, if present the foxtail stonewort will probably be lost due to nutrient enrichment. Loss of submergent macrophytes in the Broadland forces herbivores to concentrate of swamp species, to the detriment of *Phragmites* (Rodwell, 1995). It has also been suggested that smothering by filamentous algal mats my deprive young shoots of oxygen and light by smothering but see smothering above.

Gammarus salinus has been associated with polluted waters (see reviews), while most epiphytic and epistatic grazers would probably benefit from the increased algal growth stimulated by eutrophic conditions.

Overall, the extent and growth of *Phragmites* may benefit from nutrient enrichment and 'not sensitive*' has been recorded.

Increase in salinity	Intermediate	High	Low	Minor decline	Low

Phragmites tolerates salinities between 2 -12 psu (g/l) but up to 22 psu (g/l) in Poole Harbour, although bud formation is reduced at high salinities (Rodwell, 1995). Hellings & Gallagher (1992) reported that shoot density, height, biomass, underground reserves and rhizome carbohydrates decreased with increasing salinity, from 0 to 15 and 30 psu (g/l). However, stands of *Phragmites* have been reported to grow at salinities of up to 65 psu (g/l) (Hellings & Gallagher, 1992). Amsberry *et al.* (2000) reported that colonization of new habitats by *Phragmites* was restricted by physical factors including salinity but that the expanding reed bed could colonize low salt marsh habitats and hence higher salinities by clonal, vegetative growth.

The nationally rare foxtail stonewort *Lamprothamnium papulosum* was reported to prefer 8-28psu but tolerate up to 32psu. Most brackish water species are adapted to a wide range or variable salinities, e.g. *Hydrobia ulvae*, *Gammarus salinus* and *Gammarus insensibilis*, however the mysid *Neomysis integer* is predominantly brackish water and has an upper tolerance limit of 20 - 25psu (see review).

Overall, a short term increase in salinity e.g. from reduced or low to variable or full for a week would probably stress the pondweeds and a few members of the invertebrate community but otherwise has limited effects. But, a long term change from e.g. from reduced to variable salinity would probably result in decreased growth rates of the established *Phragmites* bed and increased competition with salt marsh vegetation such as *Puccinellia maritima* or *Spartina* species. In the long term the seaward extent of the biotope will probably be reduced. The invertebrate community would probably change to include more marine species with a minor decline in species richness.

Overall an intolerance of intermediate, with a recoverability of high has been recorded (see additional information below).

Decrease in salinity	Tolerant*		Not sensitive	Rise	Low

A decrease in salinity from reduced to low or freshwater would probably benefit the *Phragmites* allowing it to colonize a wider area, potentially invading other salt marsh communities, e.g. *Spartina* communities. Fell *et al.* (1998) and Able & Hagan (2000) did not detect any significant difference in macroinvertebrate, decapod and fish populations between salt marsh and *Phragmites* dominated communities. Therefore, 'not sensitive*' has been recorded. However, the marine invertebrate community is likely to decrease with decreasing salinity, being replaced by freshwater representatives. Species richness is generally low in estuarine or brackish water conditions, increasing in marine or freshwater conditions, therefore, overall species richness may rise with decreasing salinity.

Changes in oxygenation	Low	Immediate	Not sensitive	No change	Low

Phragmites australis grows well in poor oxygenated, water-logged substrata as long as the rhizomes remain aerated through the dead aerial stems. But if the stubble of aerial stems is cut too low, removed by wave action or flooded too deeply, especially by saline water, the *Phragmites* stand may be killed (Hellings & Gallagher, 1992). Water logging and reducing conditions may prevent *Phragmites* from colonizing sediment as seed or plant fragment but *Phragmites* may colonize such sediments by vegetative expansion (Amsberry *et al.*, 2000).

Most of the species identified as characterizing can probably tolerate low oxygen concentrations (e.g. benthic infauna and *Conopeum* spp.) as they are characteristic of wave sheltered and low water flow environments or are able to avoid low oxygen conditions, e.g. mobile gammarids and fish. Anoxic conditions are not relevant to aerial insects and vertebrates.

Therefore, an established stand of *Phragmites* will probably survive a reduction in oxygen concentration within the water column or substratum and an intolerance of low has been recorded.

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Richness	Confidence
Introduction of microbial pathogens/parasites	Intermediate	High	Low	Minor decline	Low

Several insect species damage reed stems or rhizomes and reduce the standing crop.

- The larvae of the twin-spotted wainscot *Archanara geminipuncta* feeds on growing internodes from the inside, killing the shoot and causing thinner, shorter side shoots to grow from beneath the point of damage. The larvae requires three shoots before they pupate and over-winter inside thick stems (Tscharntke, 1992; 1999). In outbreaks up to 96% of stems may be affected (Tscharntke, 1992). Mook & van der Toorn (1982) reported that heavy frost or twin-spotted wainscot damage reduced shoot biomass by 25-35%.
- The larvae of the large wainscot *Rhizedra lutosa* eat the inside of young spring shoots, entering and feeding on rhizomes and pupating in the soil. The insect could only complete its life-cycle in dry conditions (van der Toorn & Mook, 1982). Loss of spring shoots resulted in the production of thinner side shoots. Heavy infestation in dry plots resulted in losses of yield of 45-60% (see van der Toorn & Mook, 1982; Mook & van der Toorn, 1982).

Phragmites australis also supports several species of gall forming flies and midges, which benefit from the activities of the twin-spotted wainscot (Tscharntke, 1992; 1999). Many species of invertebrates, including crustaceans and gastropods are secondary hosts for fish or bird parasites (see individual species reviews for examples). Gastropod molluscs may also be castrated by heavy trematode infestation.

Given the evidence of loss of shoot biomass reported above an intolerance of intermediate has been recorded. Recovery is likely to be rapid.

Introduction of non-native species		Not relevant		Insufficient information	Not relevant

No information found

Extraction of this species	Tolerant	Not relevant	Not sensitive	No change	Not relevant

Phragmites australis reed beds have long been exploited commercially as a crop (see importance). Careful cutting and management is an important tool in the long term conservation of reed beds. Reed beds are more likely to decline as a result of poor management (inappropriate cutting or burning) or lack of management than as a result of harvesting. Therefore, not sensitive has been recorded.

Extraction of other species	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant

Additional information

Recoverability

Existing reed beds may expand and colonize new substratum by vegetative growth. *Phragmites australis* produces horizontal rhizomes that spread across the surface producing new vertical shoots and roots at each internode (Hawke & José, 1996). Hawke & José (1996) reported expansion rates of 1-10m per year, sometimes faster, depending on temperature and water depth. Amsberry *et al.* (2000) noted that underground rhizomes spread horizontally about 1-1.5m per year. Hawke & José (1996) reported that allowing marginal reed to colonize an area of Hickling in Norfolk, resulted in 50ha of harvestable reed within 5 years. Sowing of large volumes of seed resulted in 7-500 plants/m^2 within 3 years, although in the wild seed set and survival is low. Therefore, in favourable conditions or favourable management regime, recovery or colonization from existing, adjacent populations is likely to occur within about 5 years. However, spring frosts, insect or grazing damage, and changes in the emergence regime may hinder recovery.

Where the population is completely removed, recovery will depend on colonization by seed or fragments of plant, especially rhizome. Seedlings are rare in the field and usually associated with mineral soils and areas of habitat disturbance, i.e. devoid of other macrophytes (Haslam, 1972; Amsberry *et al.*, 2000). Boedeltje *et al.* (2001) studied colonization of created shallow water zones along navigation canals in the Netherlands. *Phragmites australis* communities occurred late in the succession in plots older than 3-5years, requiring areas in which a thick layer of sediment had accumulated, for example, a well developed *Phragmites* - *Urtica* community (NVC S26) characterized 13 year old zones. NVC S26 is more characteristic of dryer zones than NVC S4 and probably represents a later stage in the hydrosere than NVC S4. Therefore, where the community is removed completely recovery may be protracted.

The epiphytic species will probably recruit to the available habitats quickly, as will mobile species such as crustaceans, insects, and fish (see recruitment). Rare species, e.g. bittern, foxtail stonewort, the reed leopard moth and Fenn's wainscot, may take longer to recruit to the developing reed bed, partly due to isolation of breeding populations and partly due to their different habitat size requirements. Species that need large reed beds would probably not recruit until an adequate reed bed size was attained.

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