Information and Advice note

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for birds
for people
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Reedbed design and establishment.

Introduction

The creation of new reedbeds has been a priority for conservation action in recent years, with considerable progress being made towards biodiversity action plan (BAP) targets for reedbed and Bittern. By 2003 at least 800 ha of new reedbed had been created, or was in the process of creation, and more is in the pipeline. Much information has been generated on reedbed design and establishment, and work on the ground combined with continuing research into particular aspects of reedbed or species ecology, has continued to add to our knowledge and experience. This Information and Advice Note is a result of discussion amongst RSPB staff involved in reedbed creation and management, as well as the experience of partner organisation and individuals. It aims to present an up-to-date summary of the techniques involved in creating and establishing a reedbed that provides significant benefits to the key associated species.

The habitat requirements of key reedbed species

Much effort has been targeted towards conservation of the Bittern, a bird of the 'wetter end' of the reedbed. However, although a key problem within UK reedbeds has been natural succession and associated drying, it is important to understand and provide for the requirements of species across the range of reedbed conditions.

Birds

Considerable research into Bittern ecology continues to clarify their requirements, these are summarised below. The requirements of other reedbed birds of conservation concern are given in Table 1.

Bittern Habitat Requirements

The most recent research on the habitat preferences of Bitterns in the UK (Gilbert *et al* 2003) concludes that:

- Bitterns prefer big, wet reedbeds with plenty of open water and reed/water edge.
- Although Bitterns will breed in reedbeds of a wide range of sizes (3-380 ha in the UK), new reedbeds should ideally be as large as possible (c.100ha if possible) to accommodate habitat variation, especially if in areas without smaller satellite reedbeds nearby. Bittern home ranges (studied on sites >100ha) are around 20ha on average, increasing in the non-breeding season.
- With regard to reedbed structure, the most important parameter providing feeding habitat is the area of wet reed (growing in water) within 30 metres of pools. Ditches connected to pools can increase the suitability of a site. The reed/water interface is critical, with 250-400 metres of reed edge per hectare being the ideal target – this will necessitate a great deal of complexity in the interface. Open pools occupy on average about 30% of the Bittern home range.
- In the UK, breeding Bitterns use reedbeds with water depths between 15-30 cm within the reed. However, on the continent there is a wider range of tolerance and occupied sites in northern/eastern Europe may have depths of up to 1 metre of water within the reed.
- When seasonal water level changes occur, Bitterns will move to maintain ideal feeding depths. They will also move outside key reedbed areas to other feeding sites. Therefore maintaining variation in topography will maximise opportunities for Bittern throughout the year.
- Clearly, as a piscivorus bird, fish are critical for the Bittern and reedbed design must provide conditions suitable for sustainable populations (see below).
- When choosing a nest location, female Bitterns tend to have less scrub nearby and more reed/pool edge. The block of continuous reed in which they nest is on average 2ha. Immediately around the nest, they

avoid vegetation indicative of dryness, and water levels around the nest are generally high even at the driest part of the season.

Table 1: Birds of conservation concern likely to benefit from reedbed creation.

Species	**BoCC* Status**	**Requirements for nesting**	**Requirements for feeding**
Bittern	Red	Large,wet reedbeds. A continuous reed block of c2ha, wet throughout the season.	Principally fish, but also amphibians, crayfish, mammals and birds, taken from within extensive wet reed/open water interface.
Marsh Harrier	Amber	Tall vegetation, traditionally reedbeds but recently also arable fields.	Small birds and mammals found in and around wetlands.
Teal	Amber	Tussocky marsh vegetation near shallow water.	Aquatic invertebrates and weed seeds in shallow, muddy pools.
Shoveler	Amber	Tussocky marsh vegetation near shallow water.	Aquatic invertebrates and weed seeds in pools.
Water Rail	Amber	Tall dense clumps of marsh vegetation in shallow standing water.	Varied, mainly invertebrates but also small fish, amphibians, berries and shoots.
Spotted Crake	Amber	Mosaic of flooded and moist habitat with tall vegetation in wet grassland or poor fen.	Varied, mainly invertebrates but also small fish, berries and shoots.
Grasshopper Warbler	Red	Dense ground cover, including tall marshy vegetation.	Mainly insects picked from the ground or from vegetation.
Savi's Warbler	Red	Large wet reedbeds	A variety of small invertebrates.
Marsh Warbler	Red	Areas of fen, marsh and scrub vegetation, usually close to water	Mainly a variety of insects and spiders.
Bearded Tit	Amber	Dry or mixed wet and dry reedbed and litter with a high reed/water interface	In summer mainly invertebrates, in winter mainly seeds.
Reed Bunting	Red	Tall, marshy grassland, ditch edges, crops and set-aside.	Insects and weed seeds.

**BoCC= Birds of Conservation Concern: 2002-2007 (RSPB) Red = high concern, Amber = medium concern.*

Non-avian species

Aquatic flora

- Ditch and waterbody profiles within the reedbed should provide abundant shallow water for submerged macrophytes and emergent vegetation. Subsequent management should allow for a full range of seral succession, from open water to vegetation choked ditches. Areas of deeper water (> 1.5m) are required to reduce the potential for reed dominance.
- Species presence depends on water pH, salinity and trophic status. Most aquatic plant species prefer mesotrophic-eutrophic conditions with a neutral to slightly acidic pH. New reedbed landforms should therefore ideally avoid using topsoils or other nutrient-rich substrates.

Invertebrates

- All stages of the reedbed succession support important invertebrate communities (Kirby 2001). Maximum diversity is supported by reedbeds with damp, but not flooded, litter layer and an abundance of other reedbed herb species. Sparse reed with other emergents in shallow water is good also. Research in France has suggested that maximum invertebrate food for reedbed passerines was available in wetter areas (Poulin *et al* 2002).
- Reedbeds are particularly noted for a number of scarce moths. Wet reedbeds are favoured by those species whose larvae feed and pupate within the foodplant. Characteristic species include the Rush Wainscot and the Brown-veined Wainscot. The larvae of the micromoth *Schoenobius gigantella* find fresh food by floating from stem to stem on a raft of reed stem. Drier reedbeds favour those species that pupate in reed litter or underground; these include Fen Wainscot, Silky Wainscot, Reed Dagger, Fenn's Wainscot and Reed Leopard.
- Some invertebrates associated with reedbed feed on the reed itself; others are predators or parasites of these species. A further group live within reed stems but don't feed on it. Many live within the leaf

litter, or are aquatic species living amongst the emergent stems. The reedbed structure is important for many of these species (Kirby 2001).

- Overall, invertebrate interests are best served if all stages of reedbed succession from young reed in open water to old reed with scrub invasion on almost dry ground over dense litter are provided. The juxtaposition of the stages can be important as many invertebrate have different requirements at various times in their life cycle. Small scale variation within a broader mosaic is likely to be desirable.
- Variation in associated habitats is also important: bare marginal substrates can be very important and shallow pools/ditches with abundant emergent and submerged aquatic macrophytes generally support a diverse invertebrate fauna.

Fish

From fish studies and Bittern prey analyses it can be concluded:

- Cyprinid fish typically exhibit seasonal variations in distribution and habitat use. Adult fish generally gather in deeper, more enclosed waters during the winter months. In the spring, more open, warm, vegetation-filled shallows less than 1.5m deep are important for spawning and sheltering fry. Fish may also exhibit diurnal variations in distribution, using the littoral zone more by day and open waters more by night.
- Fish biomass and abundance is generally greater in shallow open waters and lakes than in reedbed/ditch systems. Therefore, reedbeds will ideally contain or be adjacent to plenty of open water with abundant aquatic plants. Pools within reedbeds are preferred to ditches, although deep ditches may be useful winter habitat.
- Connectivity is vital to allow movement between seasonal habitat preferences and to ensure recruitment of eels.
- Overall, diversity in underwater structure, with variations in bed depth and deeper refuge areas, are important to ensure microhabitat preferences between fish species, and seasonally within species, are met. Artificial underwater habitat in the form of rock piles or log-jams may be created.
- The reed/water interface is crucial for feeding Bitterns. The reedy fringes must allow access and provide shelter for fish whilst at the same time provide foraging habitat for the birds. Bitterns feed mainly on those fish that use the reed edge; research has shown Rudd, Sticklebacks and Eels to be most frequently eaten, but sometimes Perch where abundant. Other species may be important in different sites. Prey sizes are relatively small (fish 6-10cm, eels a little larger) so a viable breeding population of fish, ideally Rudd , or a supply of elvers, is essential
- Large populations of fish are likely to lead to turbid water conditions caused by suspended sediments or algal blooms, whilst Bitterns feed mainly by sight and probably prefer clear waters.
- Introduction of fish requires careful consideration, not only of the range of species typical of the location but also the ease and availability of natural colonisation. Stocking is not a sustainable solution, but where the wetland design has provided all the habitat types required for the life cycle, the seeding of locally appropriate species to establish a breeding population could be considered.

Amphibians and reptiles

- Amphibians require well-vegetated waterbodies within the reedbed. Grass Snakes can be abundant in reedbeds, using piles of cut vegetation to lay their eggs. Surrounding rough grassland/scrub habitats are important.

Mammals

- Reedbeds provide excellent refuge and lying-up sites for Otters, which require abundant fish and amphibian stocks within the pools and channels.
- Water Voles can also thrive within reedbeds, which may provide a refuge from predation by Mink. Reedbed design should incorporate areas above maximum winter water levels, some isolated within the reedbed, in order to accommodate burrows and provide a winter diet of roots, rhizomes and bulbs.
- Reedbeds also provide habitat for the Harvest Mouse, which feeds on invertebrates in the summer and seeds during the winter. Water Shrews may also be present.
- Reedbeds can be used as daytime refuges by deer, whose tracks increase structural diversity.

Water regime

- Created reedbeds generally include water control structures to enable ideal water levels to be maintained. Such structures should be as simple and flexible as possible to enable rapid and effective movement of water if required. Increasingly, water levels in managed reedbeds are being kept relatively stable. However, there is considerable debate about the wisdom of such an approach and the effect it may have on the quality of the reed.

- Where cutting is required (either for conservation or commercial reasons) water drawdown to ground level or below is required to enable access. Conservation cutting to maintain reed dominance is undertaken anytime during the non-growing season, while commercial cutting is generally January-February after the reed stems have dried and the leaves have dropped.
- Reed-cutters have long argued that stagnation of water is detrimental and in support of this there is evidence of reed die-back due to unnatural water table and eutrophication (van der Putten 1997). It has been shown that phytotoxins released during the decomposition of reed litter reduce the vitality of the reed. Eutrophication and stagnant water tables may be a key factor in die-back by both promoting litter production and anaerobic conditions. Such effects have been shown to be a causal factor in the decline of the Great Reed Warbler in The Netherlands (Graveland 1998), a bird that favours the outer fringe of wet reed, and therefore may also be important for other wet reedbed birds such as the Bittern
- Reed health may therefore be promoted by reducing the build up of organic material, including its own litter. Drying out of reedbeds in early autumn may be beneficial in promoting oxidation of reed litter. In addition, increased winter water levels and through-put of water assist with the flushing of organic material.
- In summary, a natural water regime cycle with drawdown in autumn may be better for reeds than those with constantly deep water, which increases the exposure of reeds to the negative effects of litter accumulation. The ideal annual water regime may therefore have deeper winter water (up to 1 metre), dropping to a lower summer level (5-30cm), but where possible, both deeper and shallower areas to maximise benefits to wildlife. At the driest part of the year it is important to retain some wet reed and pools to allow fish refuges and Bittern feeding areas. This may be achieved by simply allowing natural fluctuations to occur or by manipulation through water control structures. Where such structures exist, water levels may also be manipulated for short periods to allow cutting or other management. A continual throughput of water would also be beneficial.

Water quality

- It is generally true that water quantity is more important than its quality – but with some qualification. Lowland watercourses frequently have elevated levels of nutrients because of agricultural run-off and treated sewage effluent. Reed grows well in such eutrophic conditions and reedbeds themselves can contribute to water quality improvement, although high nutrient levels have been implicated in some cases of reedbed decline, for example in the Norfolk Broads. However, in the creation of new reedbeds we are generally aiming for diverse aquatic systems within the pools and ditches, based on abundant aquatic macrophytes and clear water conditions. Highly eutrophic water often results in turbid, algal-dominated conditions, so ideally, the water source will have a low nutrient status.

Designing for reedbed management and interpretation

Whereas variability within the reedbed is desirable from the wildlife viewpoint, it can present problems when management is considered. Where reedbeds are to be cut, management is more straightforward where the surface has significantly sized areas of level ground. Ease of access for predators, such as foxes, also should be considered. Reedbed design therefore needs to take account of management objectives, providing appropriate access and ground conditions to enable efficient management. This will inevitably result in a compromise.

Showing people reedbed wildlife

Reedbeds can appear remarkably dull habitats to the casual visitor! Where there are visitor, interpretative or educational objectives, the design of the reedbed should provide variability, with views of edges and pools as well as access causeways into the habitat and observation hides or screens at appropriate locations. Overall, this should present no conflict with the ideal design for wildlife but does require careful consideration from the outset.

The ideal design

- <u>Habitat proportions</u>. A new reedbed should aim to provide around 25-30% open pools, 40-50% wet reed, 15-25% dryer reed and 5% scrub. Wet reed should be within 30m of a pool, or ditch connected to a pool, and have a water depth of up to 1m but a minimum spring water depth of 20-40 cm. Where

Bitterns are a target species, aim for the 'wetter' end of the habitat proportions, at least for a core area of c20 ha. Some wet reed further away from pools and ditches is ideal as Bittern females look for habitat that is not going to dry out when choosing nesting areas. The average size of reedbed blocks that females nest in is about 2ha, with an average minimum width of about 100m.

- Open water. The design should aim to provide extensive areas of water around 1m deep in spring, with fewer deeper areas to 2.0m. Open water pools are better for fish than ditches and channels. Although edge is a very important feature, it is better to increase the length of edge by creating a more complex pool edge, with perhaps some channels coming from a pool; rather than creating lots of linear channels.

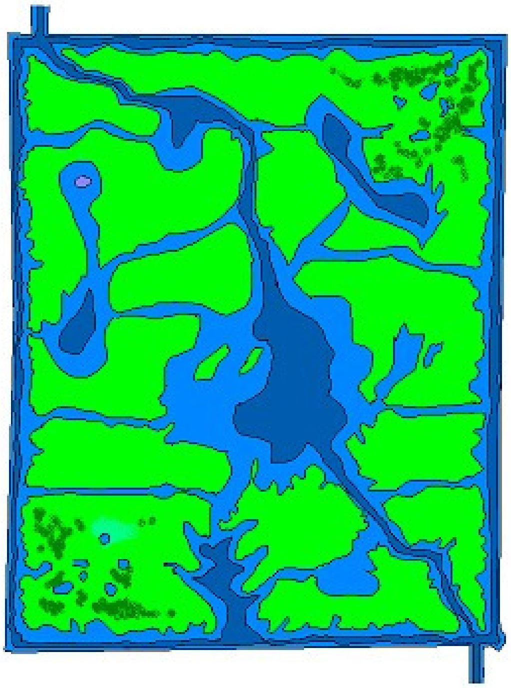
- Variability, connectivity and gradients. Landform gradients between 'zones' eg open water to wet reed, should be gentle (around 1 in 40). However, variability is valuable and all stated depths should be treated as averages, and any given zone contain 'roughness', for example the open water will on average be 1m deep but in practice have shallower bars and deeper gullies. Connectivity of water bodies is crucial to allow flow and fish movements.

- People and management. Where future management requires access for cutting, reed areas will need to incorporate access connections, with some loss of random variability. This may be compensated for by the creation of regular 'ridge and furrow' at 10m spacing. Designs need to take account of future needs to show people birds through considering edge design and visibility of waterbodies

- Nutrient status. Nutrient levels in the resultant reedbed pools should ideally be low. When landforming new reedbeds sub-soils should be used rather than nutrient-rich topsoils. It may be necessary to 'flush through' newly created sites in order to remove elements released because of the earthmoving. In addition, consideration should be given to the water source and the possibility of removing excessive nutrients prior to input.

- Introductions. In general, as little as possible should be introduced, if the habitat conditions are right and the site is not isolated, colonisation will often be rapid. In some circumstances, principally isolated sites, locally native fish should be 'seeded' to help establish breeding populations.

Figure 1. An ideal design for a 20 hectare reedbed? Areas of reed, scrub, shallow and deeper water are represented.



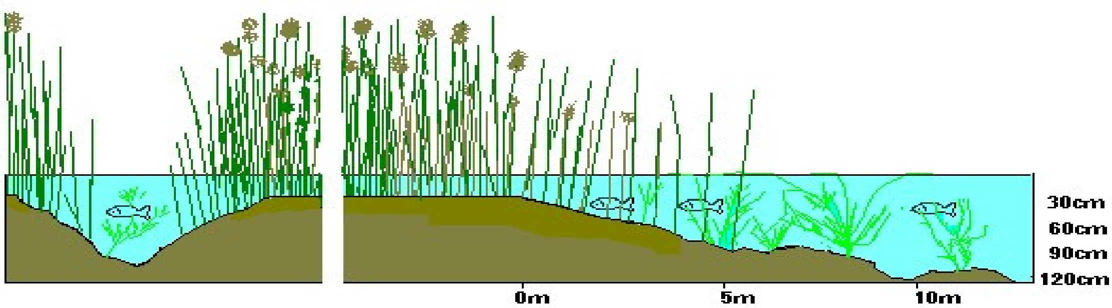


Figure 2. Landform gradients between 'zones' eg open water to wet reed, should be gentle (around 1 in 10-15).

Reedbed Establishment

Several techniques are available for establishing reed. They are well described in a number of publications (Self 2003, Hawke and Jose 1996) and this note aims to summarise the latest thinking. The techniques all have advantages and disadvantages. Each site needs to be assessed and the techniques chosen on a site-by-site basis, with water level and degree of control (as well as the time of year) often determining the technique used. The techniques include:

- Sowing seed
- Planting seedlings
- Planting cuttings
- Spreading rhizomes
- Turf transplants

Whichever technique is employed, it is not necessary to 'plant up' the whole site. Planting a nucleus of reeds in an area with good water level control creates a source of reed that can spread out into appropriately managed areas. Expansion rates vary greatly from 1-10 metres/year. The rate of expansion is likely to be affected by temperature, water depth and competition. Where reed is present in adjacent ditches natural colonisation can be rapid, especially if aided by turf transplant.

When establishing reed, consider the source of the material – seeds, rhizomes and shoots. Ideally, material should come from the site itself. If this is not possible then from some other similar local site. Planting reed taken from local sites with similar conditions will be more successful. Shallow flooding allows the site's lowest areas to be identified. These can be marked out using canes and planted following drawdown. It may also be appropriate to use the techniques in combination.

Sowing seed

Hand sowing of prepared reed panicles (generally cut into 1-2cm pieces) is currently the only available practical option. It requires careful ground preparation to ensure good soil/seed contact and to reduce weed problems, good water level management and the collection of large numbers of panicles. Where these conditions are met, sowing can be a very cheap and successful method of establishing reed. The following factors need to be considered:

- seed viability within the panicles should be tested before sowing.
- sowing should take place in still wind conditions
- soil should be saturated but not flooded, long pre-flooding may be advantageous. This saturation needs to be maintained as seedlings are very prone to drying in the early stages.
- bed should be flat and free of vegetation
- sowing should take place in May/June, ensuring the daytime temperatures range from 10-25°C and nights are frost free. Pre-germinating on a heated mat may give more flexibility with timing.
- panicle fragments should be pressed gently into the seedbed to ensure good contact. Rollers are rarely suitable, instead compression boards or trampling should be used.
- Mixing the panicle fragments in a carrier such as silver sand can be beneficial when sowing.

Seed density should be in the range 10-125 viable seeds m^{-2} (0.5-1 panicle m^{-2}) on bare, wet soil. In good conditions germination takes 3-4 days. The seedbed must be kept wet without over-topping seedlings. Rainfall during this period can wash seeds and seedlings away and is a risk. Once shoots have reached a height of 100-200 mm, the bed can be flooded to 50 mm.

Planting seedlings

Planting out pot-grown seedlings of known origin is the most widely used method of establishing reedbed, though it may also be costly and labour intensive. Planted out seedlings are more able to compete and survive adverse weather conditions. If the bed conditions are suitable, success rates are close to 100%. Buying nursery-grown material is expensive, although costs are reduced if buying in bulk for large-scale projects. For large-scale planting it may be more cost-effective to grow your own.

Pot-grown material can be planted out by hand using a dibber to create a hole of sufficient size. Individual seedlings are usually planted at densities of 1-4 m^{-2}. At the higher density, planting time is approximately 540 person hours ha^{-1} (Mills *et al,* 1999). Mechanical planting is currently at an experimental stage. It is best to plant in June, as early as possible after the frosts have ceased. Planting any later leaves plants vulnerable to competition. Water levels should be at or just above the soil surface. An alternative option may be to plant big seedlings late in the season after competition has been controlled.

Where good water level control exists, bed preparation is less important, as water levels can be used to discourage most weed species (although an initial topping of existing vegetation is beneficial). Seedlings less than a year old can tolerate water levels up to 200 mm above the topmost shoots, but only for short periods. Species established in the first year of wetland creation tend to maintain their status in subsequent years. However, under ideal conditions, reed is likely to out-compete in due course and some areas of mixed vegetation should be seen as beneficial.

Planting cuttings

Stem cuttings are easily cut and planted but have widely differing success rates, often very low. This approach is limited to a short period of the year. A donor area of 100 m2 will yield around 100,000 stems. Stems can be cut cleanly with scissors or a grass-hook in May and June with as many nodes as possible retained. Cut stems can be stored in water but should be planted on the same day if possible. The bases should be planted into water. A hole can be pushed into the soil with a metal rod with a diameter slightly less that the stem and at least 2 nodes pushed in.

Transplanting rhizomes

Transplanting rhizomes, either by spreading rhizome-rich soil or using turves, can be a quick and successful method of establishing reed and has the added advantage that litter and soil invertebrates are also introduced to the site together with plants that may be of conservation value. It is most useful on smaller project sites where donor material is located close by.

Spreading soil containing rhizomes

This technique involves the transfer of the top 300-500 mm of an existing reedbed to a prepared recipient site. Rhizome-rich soil is often excavated during the maintenance of drainage channels and can be used for this purpose. The following points should be considered when using this technique:

- the soil should be spread at least 250 mm deep
- the soil must be moist and must not dry out, but equally should not be saturated as bare rhizome fragments need to have some contact with air
- soil manipulation should be minimised to avoid damaging rhizomes and the material should not be stored for long periods
- excavation and spreading should ideally be carried out in the winter, but avoid frost on exposed rhizomes. Excavation should be to just below the rhizome level; the depth varies according to the site
- it may be necessary to pre-excavate the recipient site to achieve desired water levels and easier future management.

Spreading rhizome-rich soil in this way is only really practical over small areas as 2,500 m^3 of material is required per hectare. Transportation costs over long distances are also prohibitive. Alternatively, loads of excavated rhizomes can be dumped at 10 m intervals, ie 100 ha^{-1} across the proposed reedbed area.

Turf transplants

Cutting turves as complete rhizome mats decreases damage and reduces the volume of material to transport. This technique can be very successful. On a small-scale, turves can be cut by hand with a spade, but for large-scale projects diggers with buckets capable of digging 1 m x 1 m turves are required. The same equipment is used to cut the recipient hole. The spacing of planting depends on the size of the turves and the desired rate of spread. The following points are important:

- Larger turves contain more undamaged material and will establish a reedbed more quickly.
- Water levels may be from just below the surface to up to 500 mm deep providing turves have long, intact reed stems attached.
- Bed preparation is less critical, providing flooding is immediate to suppress competition.
- When transported or stored, turves should not be stacked one on top of the other, as this damages aerial stems which supply oxygen to the rhizomes.
- Where large machinery is already on site for landforming, the positioning of rhizome turves at the end of the process can be a cost-effective and efficient method of starting reed establishment.

Reedbed protection

The first season after sowing/planting is the most critical for reed survival with drought, weed control and wildfowl grazing all being important factors. Problems can be very costly to resolve in terms of money and delays to reed establishment.

It is necessary to protect the establishing reedbed from competition with other plants and from grazing animals in the first year. Newly-sprouted reed is eaten by a variety of grazing animals, eg geese, coots, deer, rabbits and livestock, and this can seriously inhibit reed growth/expansion. Some form of fencing is essential. Plastic netting with tape stretched across the enclosure has been successful at some sites to protect new plantings from grazing, but needs to be combined with regular human disturbance of the site. At other sites, complete cover with netting has been required to keep birds such as Coot out of the enclosures. Other possible solutions include minimising the area of open water in the early stages to reduce attractiveness to water birds, as well as bird scaring devices such as rook scarers, plastic bags on tall sticks etc..

However do not be pessimistic! Given time and the correct conditions, reed will out-compete other species. In general, a slower expansion of reed with a complex reed/water interface and a mix of other species, is better than a dense reed monoculture. Finally, a good monitoring programme is invaluable to the project itself and to others.

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