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ECOLOGY AND USE OF PHRAGMITES COMMUNIS IN EASTERN CANADA

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ABSTRACT

The common reed (*Phragmites communis* Trin. = P. *australis* (Cav.) Trin. ex Steud.) is a cosmopolitan perennial grass. In eastern Canada, it can attain a height of up to 5 m and extends north to 49° . At this latitude, the species probably encounters the coldest conditions it can support. Heliophile, hygrophile, gregarious and aggressive, the plant reproduces primarily vegetatively. The colonies, practically all monospecific, expand in shallow waters (maximum 1-1.5 m) and disturbed areas such as roadsides and ditches. The distribution is limited by lack of water, nutrients or light and by excessive salinity. The nature, texture or pH (3.8 - 8.0) of the substrate, appears to have little influence. In contrast to other regions in the world, where the species is used as a construction material, as fiber for paper production or as fodder, the Amerindians used it particularly for food: as boiled or roasted rhizomes, as dried shoots ground into flour, as cooked grain, or as leafage exudate for sugar. Today, the plant is being used in habitat restoration of wetlands and in water purification systems. In such systems it is recommended that local provenances be used and contained between two rows of woody species, such as *Salix* and *Thuja*, in order to prevent uncontrolled expansion of the colony and potential risk to crops, drainage systems or avifauna.

INTRODUCTION

According to Clayton (1968), the correct name of the common reed, usually called *Phragmites communis* Trin., is *P. australis* (Cav.) Trin. ex Steud. The American plant might be better designated as *P. communis* var. *berlandieri* (Fourn.) Fernald (Fernald 1932, Marie-Victorin 1995).

The common reed is a cosmopolitan, large perennial grass, with a presence on all continents (Holm *et al.* 1997). In eastern Canada, where it appears to be expanding along highways, it may reach a height of 5 m while the average is about 2 m. Realizing that this apparently aggressive colonizer was being considered for use in water purification systems (Phragmitech n.d.) and that it could represent a potential threat to crops, drainage systems or avifauna (Rushforth Guinn 1984, Vézina 1989), several authors Mousseau (1987), Gervais *et al.* (1992) and Gervais *et al.* (1993) became interested in the plant focusing on its distribution, cytology, reproduction, ecology, potential utilization and control measures. The present study is limited to an examination of the distribution, ecology, use and control of the common reed, primarily in Quebec.

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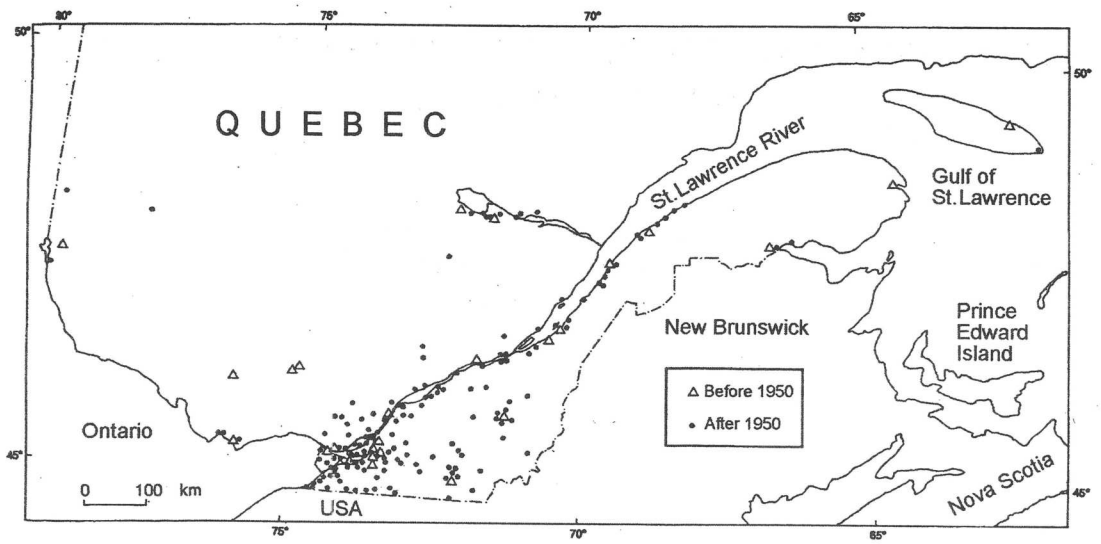


Fig. 1 Distribution of *Phragmites communis* in Quebec (Gervais *et al.* 1993).

DISTRIBUTION

Figure 1, from Gervais *et al.* (1993), illustrates the distribution of the species in Quebec. Herbarium collections, made prior to 1950, are marked by triangles while black dots denote the sites where the plant was collected between 1950 and 1985. Comparison of the present distribution with that prior to 1950 indicates that, as was previously reported by Vézina (1988), the species is aggressively expanding in the southwest section of Quebec.

What factors are responsible for this expansion? Our observations agree with those of Mousseau (1987) and Gervais *et al.* (1993). These authors attribute this expansion to the development of roads and ditches and the movement of soil, material and machinery. The leveling and spreading of soil and the displacement of heavy equipment may result in the transportation of rhizomes and lead to the vegetative reproduction of the species. Reproduction by seeds is also a possibility since the seeds from across the entire distribution range of the plant have demonstrated the ability to germinate, at least in laboratory studies (Gervais *et al.* 1993). Whether or not the plant propagates in this manner *in situ* remains to be confirmed through direct observation of germination of seeds that have fallen to the ground or through experiments where seeds are planted (Gervais *et al.* 1993).

It is also possible to observe, from Figure 1, that the common reed reaches the northern limit of distribution in Quebec on Anticosti Island, at a latitude of 49℃. This northern limit is similar to that reported by Rousseau (1974) and the limits of distribution of the species have essentially not changed. The difference occurs in the fivefold increase in the total number of sites where the plant has been reported. This increase has resulted in the distribution range becoming almost continuous in the southwest of the province.

ECOLOGY

The distribution range of a species is primarily dependent on the capacity to adapt to various habitats and the changes occurring in these areas. Such is the case for the common reed. The

ecological requirements of the species in Quebec are known partly as a result of work carried out by Dansereau (1959), Blouin & Grandtner (1971), Lamoureux (1983) and Gervais *et al.* (1992). Outside Quebec, particularly in Europe, there are numerous studies on this species. The principal publications include those of Haslam (1968, 1971, 1973, 1975, etc.) and Monk & van der Toorn (1982). Mousseau (1987) has published a summary of these studies.

Light

In Quebec, the common reed prefers open sites (Lamoureux 1983) and may thus be described as a heliophile. Its height, speed of growth and the stem density permit it to effectively compete with other herbaceous species. Large shrubs and trees can, however, deprive the plant of the light required for its development (Gervais *et al.* 1992). The rapid disappearance of the species from forest borders is a direct function of the density of the forest cover. According to Haslam (1973), in Great Britain, the common reed is rather tolerant to shade although in these environments, the density of the colony and the vigor and rigidity of the plant tend to be reduced.

Temperature

While the world distribution of the common reed indicates its presence across a large thermal range, the distribution in Quebec appears to be limited by temperature (Gervais *et al.* 1992). In fact, colony frequency decreases markedly where the frost-free period falls below 120 days. Early frosts can also restrict the growth and young seedlings, except in particular microclimates. At the northern limit of the distribution range (49° latitude N), the mean annual temperature is less than 2℃ while temperatures of the coldest (January) and warmest (July) months are respectively -10℃ and 13℃. In Quebec, these conditions appear to create a thermal barrier and probably represent the coldest conditions the species encounters throughout the distribution range.

Despite a definite resistance to cold, the seedlings and young shoots are susceptible to frost. Loss due to frost kill may control colonization and eventual spread of the plant. Following Haslam (1975) the stages most sensitive to variation in temperature are germination, bud emergence and the length of the growth cycle. Germination may be particularly affected in some ecotypes. Where reproduction is vegetative, the effect is less severe, because the horizontal rhizomes are more resistant to freezing, at least in Great Britain (Haslam 1973). However, the loss of young seedlings to early frosts, remains a threat to the establishment of a new colony, whether it originates from seeds or rhizomes (Gervais *et al.* 1992).

While frost may kill emerging buds, it also stimulates the formation of two or three replacement buds, which consequently increases the stem density of the colony. Low temperature also appears to decrease growth. In southern Quebec, bud emergence occurs in May, followed by a period of rapid growth and in September, growth comes to a halt (Mousseau 1987).

Water

The common reed is generally considered to be a wetland species (hygrophile), although it can tolerate some degree of drought. In the case of flooded soils, the species makes its habitat in the riparian zone, between a low water depth of 1.5 m and the high water level. When permanently submerged, for example, at the edge of a lake, eutrophic water height may reach 4 m ($>$ 75 % of the stem height), while in oligotrophic environments it is not found beyond a depth 0.75 m ($<$ 50 % of the stem height).

Depending on the soil type, some colonies may occur in sites where the water table at low tide is at 0.75 m (Blouin & Grandtner 1971) and may even be up to 2 m. The level of the water table appears to influence stem height and colony productivity (Radoux 1977 in Gervais *et al.* 1992). This daily or annual water fluctuation does not limit the species distribution, even though it may slow down colony development. Also, in wet environments, a dry spring will retard emergence and flowering while a dry autumn will accelerate stem death. In contrast, an early spring flood

can kill young shoots and retard or even impede the emergence of young shoots (Mousseau 1987). In western Canada three successive years of flooding to a depth greater than 1 m, eliminated all plants (Shay & Shay 1986).

Certain factors associated with the water regime can limit plant density and propagation. Such cases occur where an excessive water level does not allow shoot growth above water or where wave and ice action becomes limiting. The force of the current may equally affect distribution. While a rapid current, will provoke leaching and erosion of the shore, a weak current will stimulate oxygenation. Generally, in Quebec, as elsewhere, the common reed grows in dormant or stagnant waters.

Salinity

Salinity may become another factor limiting the expansion of the common reed, found in fresh or brackish waters. In Quebec, water salinity has not been investigated. The location of certain colonies suggests that they are probably in contact with brackish water or spray. In addition, those colonies occurring in roadside ditches, may also be subjected to salinity from the winter accumulation of de-icing salt in these areas. As pointed out by Gervais *et al.* (1992), none of the known sites have sufficient salt concentrations to inhibit seed germination or plant growth. As described by Haslam (1973) from Great Britain, the lethal concentration of salt solution is in the range of 10 to 15 ‰, depending on whether young or old plants are involved. In Connecticut, USA, Sinicrope *et al.* (1990) reports that throughout the course of rehabilitation of a salt marsh, the common reed developed rather than cattails (*Typha*) because it has a greater tolerance to salt. The same authors point out that the most rigorous colonies of the common reed can withstand 20 ‰ salt solution concentrations. However, at 30 ‰, the colonies show poor growth and a reduction in size (height 0. 3-1.0 m). In Delaware, USA , Roman *et al.* (1984) have also observed that the common reed invaded salt marshes where the salinity had decreased as a result of the obstruction of the entrance to sea water. In Japan, Matoh *et al.* (1998) report that growth of the species *in vitro* was affected by NaCI solutions of 16.6‰. Finally, Haslam (1973) and Mook & van der Toorn (1982) mention that seedlings are particularly sensitive to increases in salt concentrations and that the germination potential decreases at solution concentrations as low as 6.6‰.

Soil

According to Mousseau (1987) and Gervais *et al.* (1992), the type and texture of soil have relatively little influence on the distribution of the common reed except in the case of a coarse textured soil, low in nutrients and exposed to erosion. In Quebec, the plant colonizes varying classes and textures of soil, ranging from clay and sand to gravel and peat (Blouin & Grandtner 1971, Mousseau 1987). In disturbed areas and roadsides, clayey, sandy and gravelly textures tend to predominate.

The litter that covers the soil can inhibit bud and stem emergence and consequently affect colony density (Radoux 1997 in Gervais *et al.* 1992). On the other hand, in the absence of litter, young shoots may suffer from freezing and ultimately, result in the inhibition of future stem development.

The species grows very well across a wide range of pH. The values obtained by Blouin & Grandtner (1971: pH 5.2) and by Gervais *et al.* (1992: pH 3.8-8.0) correspond to similar values reported in the literature. The pH values do not appear to have a relationship to size or stem density of the colony.

With respect to soil richness, the only soil profile analyzed in Quebec by Blouin & Grandtner (1971) had a cation exchange capacity of 100 m.e./100 g with a base saturation of 80 %. The principal elements were sodium (46 m.e./100 g) and magnesium (20 m.e./100 g). In environments low in nutrients, competing species are usually rare. In eutrophic environments, on the contrary,

the competition is abundant and rich. In fact, the common reed often forms denser colonies in areas where nutrient richness is average because in richer environments, other species become more competitive (Mousseau 1987).

Phytosociology

Phragmites communis often forms monospecific groupings, referred to as *Phragmitetum laurentianum* (Dansereau 1959, Blouin & Grandtner 1971), that may spread to cover several hectares. This is a plant that possesses a great potential for colonizing bare or disturbed soils. These communities tend to stabilize in the presence of other established plant associations, such as *Typhetum laurentianum* (Dansereau 1959), without forming a continuum with the latter. In addition to *Typha latifolia* and *Typha angustifolia,* other species found bordering *Phragmitetum* include *Atriplex hastata, Spartina patens, Aster simplex* and *Hordeum jubatum.* The position of the community in a toposequence of halophiles in Quebec is illustrated in Figure 2. In this area, the community is found on a natural levee built up by the Loup River. The site is submerged both by the daily tide and with fresh water from the river.

According to Haslam (1971), and from our observations, the common reed can also grow in the presence of a large number of species and form mixed associations. The latter are more common where competition is low, such as in environments that are drier, more oligotrophic, have higher salt content or have experienced greater disturbance by man. On the banks of the Baltic Sea, for example, *Phragmites communis* is found in associations dominated by *Scirpus maritimus, Juncus gerardii, Spergularia salina, Carex mackenziei, Festuca arundinacea* and *Elymus arenarius.* The coefficients of abundance-dominance and of sociability, following Braun-Blanquet as slightly modified by Grandtner (1974), remain relatively low, varying from +.1 to 2.2 respectively, and correspond to < I to 25 % cover and from1 (isolated) to 2 (clumped) in sociability.

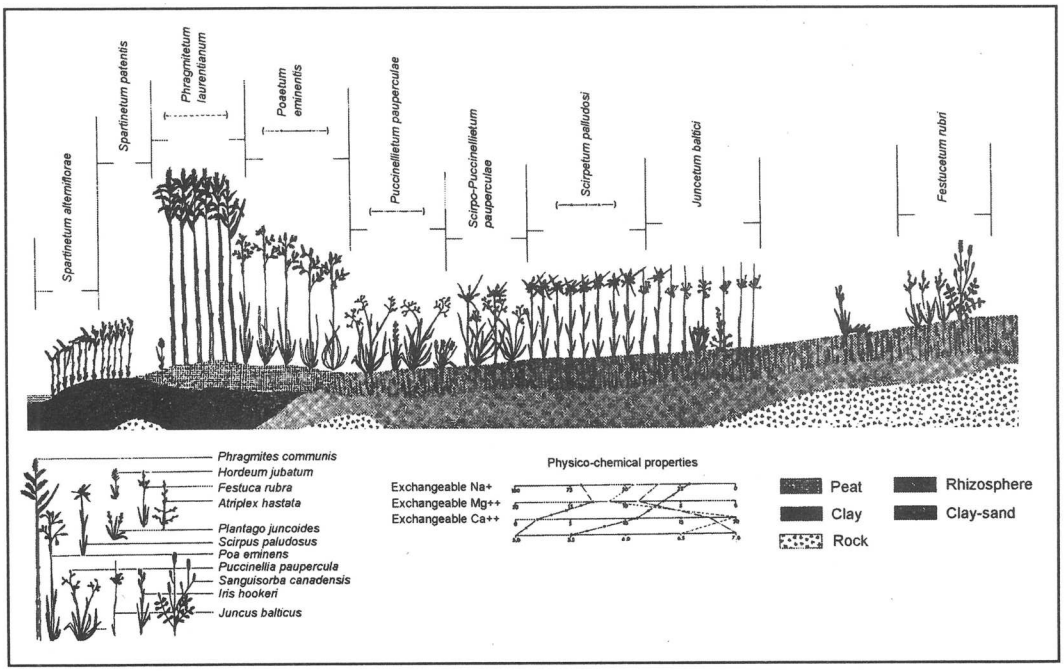


Fig. 2 Position of *Phragmitetum laurentianum* in the toposequence of halophile communities at Rivière-du-Loup, Quebec (Blouin & Grandtner 1971).

Avifauna

A certain number of birds, of the sturnid (Sturnidae) and the emberizid (Emberizidae) families), commonly referred to as black birds, that are apparently a menace to crops (Mousseau 1987), use the common reed as a perch and as a nesting or other occasional habitat during the migration route. These birds include the starling (*Sturnus vulgaris*), the red-winged blackbird (*Agelaius phoeniceus*), the common grackle (*Quiscalus quiscula*), the rusty blackbird (*Euphagus carolinus*) and the brown-headed cowbird (*Molothrus atar*). However, it has not yet been proved that the birds are dependent on the common reed (Gervais *et al.* 1992).

Some authors, like Rushforth Guinn (1984) and M. Savard (pers. comm. in Gervais *et al.* 1992) believe that the dense reed colonies are unattractive to waterfowl and may even contribute to a reduction in avian diversity. Riemer (1976) considers that the species has a low nutritive value for birds compared to that of cattail (*Typha* sp.) bulrush (*Scirpus* sp.) and smartweed (*Polygonum* sp.) which, by its aggressive growth pattern, the common reed will eventually eliminate. These opinions still require validation.

USE

Historic

Man has made several uses of the common reed. One of the earliest uses was as fencing to delimit pasture surrounding the huts of agricultural tribes. The species was later used as a construction material, especially for roofing but also as latticework, matting, arrows, writing pens, flutes, etc. . The Amerindians used the reed as food; the rhizomes were roasted or boiled, young shoots were ground into flour, the exudate from the sap was used as sugar and the whole seeds were boiled. It appears that a successor to coffee was prepared with roasted rhizomes and when fermented the roasted rhizomes produced an alcohol or dark beer (Lamoureux 1983). Several additional uses of this plant also warrant mention.

Cellulose

The cellulose content of the common reed varies from 27-69 %. The fibers are long (0.9-2.0 mm). The pulp produced is of inferior quality. However, when used in combination with other fibers of higher quality, for example, a mixture of 20 % common reed and 80 % other fibers, a good quality paper can be produced (Rudescu *et al.* 1965). In Romania, other products such as cellophane, synthetic fibers, alcohol, fuel, fertilizers, cardboard, etc., are produced from residues of the common reed.

Energy

Colonies of the common reed have a high energy potential. In fact, in USA and Sweden, the possibility of pressing the plant into compact bricks for use as a heat source for greenhouses and farms has been investigated (Mousseau 1987).

Fodder

In France and Scandinavia, the common reed is an excellent candidate fodder for all herbivorous mammals. The protein to fiber ratio of young shoots is high (23 : 31 %). The species would thus be a preferred source over other monocotyledons. However, the common reed is very sensitive to grazing (Duncan & D'Herbes 1982 in Mousseau 1987).

Protection

Holm *et al.* (1977) reported that the common reed can be used effectively as a ground cover to protect against erosion. In addition, the riparian colonies, where they occur at high density and where the slope of the bank is appropriate, can dissipate more than 60 % of the wave force produced by boats.

Restoration

In USA, the common reed is used in salt marsh restoration, especially in Connecticut (Sinicrope *et al.* 1990) and Delaware (Roman *et al.* 1984).

Water treatment

According to Phragmitech (n.d.), Vymazal *et al.* (1998) and Vymazal (1999), several countries, including Canada, USA, Great Britain, Germany, France, Denmark, Austria, Saudi Arabia, and India use the common reed for purification of domestic and industrial waters. The process, developed in Germany, in the 1970's, by Reinhold Kickuth, at Kassel University, is based on the autoregulatory dynamics of a common reed colony. The plant draws oxygen into the rhizosphere, creating conditions favourable for the rhizosphere bacteria that oxidize impurities. Water enters the system horizontally, moving through the rhizosphere where impurities are removed (Figure 3). Otsuki (1983 in Mousseau 1987) reported that the species showed the capacity to eliminate suspended solids and nutrients in Japan.

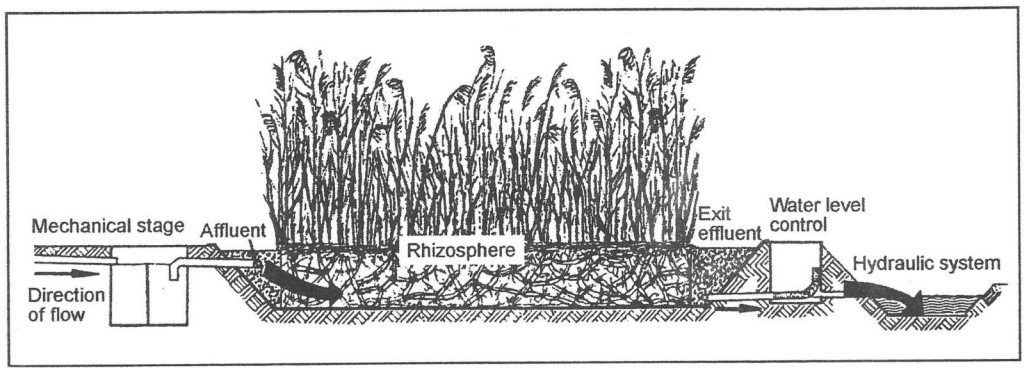


Fig. 3 Water purification system using the rhizosphere activity of *Phragmites communis* (Phragmitech n.d.).

Negative impacts

Unfortunately, in addition to the previous attributes, several authors such as Holm *et al.* (1977), Rushforth Guinn (1984), Mousseau (1987), Vézina (1988) and Gervais *et al.* (1992) have described some negative impacts of the common reed. The three potential threats include invasion of crops, harmful effects on drainage and replacement of plant species that are more attractive for bird species. The common reed is considered as a weed with respect to cotton, corn and rice crops in Russia, Greece, Portugal and Taiwan. In Quebec, however, the reed rarely invades corn or wheat fields. It propagates especially in asparagus and strawberry fields and on prairies. It may also interrupt water circulation in drainage channels and the roots and rhizomes tend to block underground drains. Consequently, the use of the common reed in water treatment and restoration projects requires control measures.

CONTROL

Cutting

The common reed reacts differently to cutting depending on the season when it is cut. Regeneration following a cut is variable and may lead to an increase in colony density or an important reduction in colony size. A cut done when emergence is just beginning will provoke a

complete replacement of the population with one of similar size and density (Haslam 1968, Mark & van der Toorn 1982, Mousseau 1987). If, following such a cut, the colony is exposed to frost, the new shoots will be more dense, but the height will be lower than average.

If the cut is done towards the end of the period of emergence, the new growth will only be partial. However, if cutting follows emergence, the new growth will probably be limited (Haslam 1968). Cutting at the end of the growing season will have less effect on the population, because the reserves will already have been stored and the rhizomes will have propagated.

Repeated annual cutting, over several consecutive years, may have a negative effect on density and lead to the disappearance of the community (Haslam 1968). Cutting below water or flooding the stems with 20 cm of water, following a cut, may also provoke mortality of the common reed (Rushforth Guinn 1984).

Fire

Burning dormant plants may cause early and rapid bud emergence in the spring. However, a fire in the spring may lead to new growth that is much denser because fire stimulates replacement buds (Haslam 1973). Obviously a fire in a wet area will have little effect on stem density because it will not stimulate bud development.

Finally, if, following a fire, the stubble is covered by water to a depth of 20 cm, the plants will die. On the other hand, if a fire occurs early in the spring and exposes the shoots to frost, the result may be an increase in the production of replacement buds (Haslam 1971, 1973; Mook & van der Toorn 1982).

Water level

As a result of its capacity for adaptation, the common reed is difficult to control solely by adjustments in water level. In any case, an increase in the water level leads to a decrease in stem height and a change in colony structure. The Ducks Unlimited Canada Association took advantage of this effect in the Beauharnois canal in Quebec. After three years of increasing the water level, common reed cover decreased from 100 to 25 %. This decrease also stimulated new species of aquatic plants to colonize and exposed some open water surfaces, which are much appreciated by wildlife (waterfowl and musk rat). This new environment was less attractive to black birds (Laviel & St. Georges 1984 in Mousseau 1987).

Tilling

Tilling and working the soil with a bulldozer are also means used for thinning or controlling common reed colonies (Mousseau 1987). Cutting the rhizomes, however, can stimulate bud production and consequently encourage the new growth to be denser. According to Haslam (1968) the rhizome fragments may be viable if they have at least three nodules, are 20 cm in length, and occur near the surface of the soil where the hydrological conditions and aeration are adequate. Tilling depth is very important especially in areas where the water table is low or where there is deep rhizome penetration. If tilling is carried out in association with flooding, the colony may become more sensitive to other control measures.

Grazing

If grazing occurs while the shoots are covered with water, the density of the colony may be reduced. A similar result may occur if the shoots are grazed and then flooded.

In mesic or dry areas, the effects of grazing will be variable depending on the type of animal and the season. New growth will occur after spring or summer grazing if the plant has sufficient stored reserves (Haslam 1968). On the other hand, surface rhizomes may be damaged and the bud production may be reduced as a result of trampling by cattle or horses (Haslam 1971, 1973).

Chemicals

Three chemicals have demonstrated efficacy for controlling the common reed: glyophosate,

dalapon and DPX 1108 with Wk as surfactant. Among the three, glyophosate appears to have several advantages (Vézina 1989).

Opaque textile

An opaque textile has been used to reduce light penetration and inhibit photosynthesis. Use of this method, for 12 weeks, reduces macrophyte biomass, including that of the common reed. The advantages of this method are that no machinery is required and there is no risk of water contamination.

Combination treatment

In Quebec, two treatments have been used by Ducks Unlimited Canada. The first consists of drying a plot followed by burning, tilling and finally, flooding with water to a depth of more than 50 cm for one and a half years. In the second method, the stems are crushed using a bulldozer, rather than burning, followed by tilling, as described in the first method. Both treatments have been successful in reducing stem density from approximately 80 to around 0.5 per m^2. These combination treatments have resulted in the replacement of the common reed by cattail and in creating open water which ultimately is a more productive wetland habitat for wildlife (Mousseau 1987).

Mitigation measures

The following mitigation measures address water treatment systems. Gervais *et al.* (1992), recommend the use of local provenances of the common reed. If it is necessary to import from other areas, a less fertile colony should be selected. It is also suggested that the treatment sites be protected from wind and that they be surrounded by woody plants in non-wooded areas, near agricultural zones and in natural wetlands. An example of such an installation would be a double hedge with cedar (*Thuja occidentalis*) on the outside and a row of either willow (*Salix* sp.) or alder (*Alnus incana* ssp. *rugosa*) on the inside. Providing protection from the wind enhances growth of the common reed in the water treatment system as well as restricting the dissemination of its seeds. System operators should also confine the stolons around the treatment site by keeping them pruned, in order to prevent undesired invasion of bordering drainage fields and ditches.

CONCLUSIONS

The common reed is a cosmopolitan, perennial grass, present on all continents. In Quebec, the distribution was rather scattered until the 1950's. Since that time, it has rapidly spread in the southern zone of its distribution, especially along the extended network of roadways.

There are relatively few North American studies on the ecology of the species. Consequently, we have referred to European literature, realizing that there will be differences in the sensitivity of the species to the different environmental conditions as a result of the differences in varieties, and probably ecotypes and chromosome races. In general, the taxon is a pioneer, heliophile and a hygrophile. It is gregarious and aggressive, at least in the southern part of Quebec, and reproduces mainly vegetatively, although viable seeds are produced throughout the entire distribution range.

The young plants are sensitive to conditions of light, temperature, water level, salinity and the nutrient level of the soil. Adult populations tolerate daily and annual fluctuations in water level that are not limiting to the distribution but which may affect the density of the population. The plant adapts to a wide variety of soils except for coarse textured soils, poor in nutrients. Grazing and trampling by cattle can result in a weakening of the colony and its eventual disappearance, if the disturbance continues over several consecutive growth seasons.

Since antiquity, man has made use of the common reed in various ways. The plant has been used as a construction material, food and fodder. Today it is still used as a fuel, to purify water and

to make paper. However, in some applications, as is the case in Quebec in wetland restoration or in water treatment plants, the common reed can negatively impact the environment. In such cases, it is recommended that local provenances be used and that the plant is maintained between two rows of woody plants such as Salix and *Thuja*. This containment should restrict the expansion of the plant beyond the treatment system where it could effect crops, drainage systems or avifauna.

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