9 Common Reed

B. Blossey,[1] M. Schwarzländer,[2] P. Häfliger,[3] R. Casagrande,[4] and L. Tewksbury[4]

[1]Department of Natural Resources, Cornell University, Ithaca, New York, United States
[2]Biological Weed Control Program, PSES Department, University of Idaho, Moscow, Idaho, United States
[3]CABI Bioscience Centre Switzerland, Delémont, Switzerland
[4]Dept. Plant Sciences, University of Rhode Island, N. Kingston, Rhode Island 02881

PEST STATUS OF WEED

Common reed (Fig. 1), *Phragmites australis* (Cav.) Trin. ex Steudel, is a widely distributed clonal grass species, ranging all over Europe, Asia, Africa, America, and Australia (Holm *et al.*, 1977). Extensive reed beds are protected in Europe (Tscharntke, 1992) because of their important ecological functions. In contrast, the rapid expansion of *P. australis* in North America, particularly along the Atlantic coast (Chambers *et al.*, 1999), is considered a threat to biodiversity in natural areas (Marks *et al.,* 1994). Peat core analysis (Orson, 1999) shows that *P. australis* was an uncommon component of marshes in New England several thousand years ago. Recent genetic evidence (Saltonstall, 2002) has now confirmed that a more aggressive genotype has been introduced to North America (Metzler and Rosza, 1987; Tucker, 1990; Mikkola and Lafontaine, 1994; Besitka, 1996, Orson, 1999), probably in the late 1800s along the Atlantic coast (Saltonstall, 2002). The distribution of the native genotypes is not well known but they appear more common in the western part of the continent (Saltonstall, 2002). At present, invasive *P. australis* occurs throughout the whole of the United States, except Alaska and Hawaii; however, problems caused by non-indigenous *P. australis* are most severe along the Atlantic coast.

Figure 1. *Phragmites australis* invasion front at the Montezuma National Wildlife Refuge, New York. (Photograph by B. Blossey.)

Nature of Damage

Economic damage. *Phragmites australis* is largely a weed of natural areas and direct economic damage has not been assessed or reported.

Ecological damage. *Phragmites australis* invasion alters the structure and function of diverse marsh ecosystems by changing nutrient cycles and hydrological regimes (Benoit and Askins, 1999; Meyerson *et al.,* 2000). Dense *Phragmites* stands in North America decrease native biodiversity and quality of wetland habitat, particularly for migrating waders and waterfowl species (Thompson and Shay, 1989; Jamison, 1994; Marks *et al.*, 1994; Chambers, 1997; Meyerson *et al.,* 2000). A survey of Connecticut marshes showed that rare and threatened bird species in the area were associated with native, short-grass habitats and were excluded by *Phragmites* invasion (Benoit and Askins, 1999).

Extent of losses. Lack of long-term data makes quantification of direct losses difficult. At sites where *Phragmites* eradication programs have been instigated, such as Primehook National Wildlife Refuge in Delaware, waterfowl abundance has significantly increased following control procedures (G. O'Shea, pers. comm.). Recovery of bird communities after chemical control of *P. australis* suggests a significant habitat loss due to encroachment by common reed.

Geographical Distribution

Presently, non-indigenous, invasive *P. australis* is most abundant along the Atlantic coast and in freshwater and brackish tidal wetlands of the northeastern United States, and as far south as North Carolina. It occurs in all eastern states and populations are expanding, particularly in the Midwest.

BACKGROUND INFORMATION ON PEST PLANT

Taxonomy

Phragmites australis is a perennial monocot in the family Poaceae, tribe Arundineae (Clayton, 1967). The genus *Phragmites* includes four species, with *P. australis* being distributed worldwide; *Phragmites japonicus* Steudel being found in Japan, China, and eastern areas of Russia; *Phragmites karka* (Retz.) Trin. found in tropical Africa, Southeast Asia, and northern Australia; and *Phragmites mauritianus* Kunth in tropical Africa and the islands of the Indian Ocean (Darlington and Wylie, 1955; Clayton, 1967; Tucker, 1990; Besitka, 1996). The status of the eleven recently discovered native haplotypes (Saltonstall, 2002) needs further evaluation. All species show high phenotypic plasticity making species identification difficult (Clayton, 1967).

Biology

Phragmites australis is a clonal grass species with woody hollow culms that can grow up to 6 m in height (Haslam, 1972). Karyotypic studies in North America have identified different ploidy levels with populations of 3x, 4x, and 6x plants, but with 4x being the dominant chromosome number in modern day populations (Besitka, 1996). Leaves are lanceolate, often 20 to 40 cm long and 1 to 4 cm wide. Flowers develop by mid-summer and are arranged in tawny spikelets with many tufts of silky hair.

P. australis is wind pollinated but self-incompatible (Tucker, 1990). Seed set is highly variable and occurs through fall and winter and may be important in colonization of new areas. Germination occurs in spring on exposed moist soils. Vegetative spread by below-ground rhizomes can result in dense clones with up to 200 stems/m^2 (Haslam, 1972).

Analysis of Related Native Plants in the Eastern United States

Phragmites australis is a member of the Poaceae with more than 100 genera represented in the northeastern United States alone (Gleason and Cronquist, 1991). The closest related species to *P. australis* is *Arundo donax* L., an invasive introduced species. The most important genera to consider for their wildlife value include species of *Typha*, *Spartina, Carex*, *Scirpus*, *Eleocharis*, *Juncus*, *Arundinaria,* and *Calamagrostis*.

HISTORY OF BIOLOGICAL CONTROL EFFORTS IN THE EASTERN UNITED STATES

Research in North America and Europe began in 1998 with literature and field surveys for potential control agents (Tewksbury *et al.,* 2002)

Area of Origin of Weed

The current distribution of *P. australis* includes Europe, Asia, Africa, America, and Australia (Holm *et al.*, 1977), however, the origin of the species is unclear. The rapid spread of *Phragmites* in recent years in North America has led wetland ecologists to believe that the species may be introduced. However, *Phragmites* rhizomes were found in North American peat cores dated 3,000 years old (Orson, 1999). Several different hypotheses have been proposed to explain the recent population explosion in North America, including the introduction of more aggressive European genotypes about 100 years ago (Besitka, 1996; Orson, 1999). The absence of specialized North American herbivores of *P. australis* in North America and the lack of wildlife use are indications for the introduced status of the species (Tewksbury *et al.*, 2002). Saltonstall (2002) has compared historic and present day populations of *P. australis* from North America and other continents using advanced genetic techniques. Her results show that present day populations in North America consist of a mixture of eleven non-invasive native North American haplotypes and one distinctive introduced invasive (most likely European) haplotype (Saltonstall, 2002). The status of an additional haplotype (either native or introduced) growing along the Gulf of Mexico is still unresolved (Saltonstall, 2002).

Areas Surveyed for Natural Enemies

In 1997, literature surveys and limited field surveys in the northeastern Unites States began. Work in Europe started in 1998 with additional literature surveys and the estblishment of field sites in Hungary, Austria, Germany, and Switzerland (Schwarzländer and Häfliger, 1999).

Natural Enemies Found

Literature and field surveys (in the northeastern United States and eastern Canada) reveal that currently 26 herbivores are known to attack *P. australis* in North America (Tewksbury *et al.,* 2002). Many of these species were accidentally introduced during the last decades; only five are potentially native (Tewksbury *et al.,* 2002). Only the Yuma skipper, *Ochlodes yuma* (Edwards) (a species distributed throughout the western United States); a dolichopodid fly in the genus *Thrypticus*; and a gall midge, *Calamomyia phragmites* (Felt), are considered native and monophagous on *P. australis* (Gagné, 1989; Tewksbury *et al.*, 2002). The native broad-winged skipper, *Poanes viator* (Edwards), has recently included *P. australis* in its diet (Gochfeld and Burger, 1997) and the skipper is now common in Rhode Island (Tewksbury *et al.,* 2002). The dolichopodid fly and the gall midge *C. phragmites* are widespread in North America but appear to be restricted to native North American haplotypes of *P. australis* (Blossey, unpub. data). The European moth *Apamea unanimis* (Hübner) was first collected in North America in 1991 near Ottawa, Canada (Mikkola and Lafontaine, 1994). Larvae feed on leaves of *P. australis* and species of *Phalaris* and *Glyceria*. A second European species, *Apamea ophiogramma* (Esper), was first reported in 1989 from British Columbia, Canada (Troubridge *et al*., 1992), but it has now been found in New York, Vermont, Quebec, and New Brunswick (Mikkola and Lafontaine, 1994). Additional species such as several shoot flies in the genus *Lipara*, Dolichopodidae; a rhizome feeding noctuid moth *Rhizedra lutosa* (Hübner); the gall midge *Lasioptera hungarica* Möhn; the aphid *Hyalopterus pruni* (Geoffr.); and the wasp *Tetramesa phragmitis* (Erdös), Eurytomidae – all appear widespread. The mite *Steneotarsonemus phragmitidis* (Schlechtendal) was recently discovered in the Finger Lakes Region of New York and the rice-grain gall midge *Giraudiella inclusa* (Frauenfeld) in Massachusetts, Connecticut, New Jersey, and New York (Blossey and Eichiner, unpub.).

In Europe, at least 140 herbivore species have been reported feeding on *P. australis*, some causing significant damage (Schwarzländer and Häfliger, 1999; Tewksbury *et al.,* 2002). About 50% of these species are considered *Phragmites* specialists (Schwarzländer and Häfliger, 1999) and almost 40% of the species are monophagous. Lepidoptera (45 species) and Diptera (55) are the most important orders. More than 70% of all these herbivores attack leaves and stems of *P. australis*, and only five of the monophagous species feed in rhizomes (Tewksbury *et al.*, 2002). Of the 151 herbivore species known from outside North America, already 21 (13.9%) have been accidentally introduced (Tewksbury *et al.,* 2002).

Host Range Tests and Results

Rhizedra lutosa larvae were exposed to a number of ornamental grasses (Balme, 2000). The larvae did not feed on any of the species tested, and no host specificity screening has been conducted for any other herbivores of *P. australis*.

Releases Made

No deliberate releases have been made, but at least 21 species feeding on common reed have been accidentally introduced to North America (Tewksbury *et al.,* 2002).

BIOLOGY AND ECOLOGY OF KEY NATURAL ENEMIES

The following is a summary of life history and ecology on potential natural enemies associated with *P. australis* in North America and Europe. Species included in this list were selected according to their abundance and potential impact on plant performance. Species marked by an asterix have already invaded North America.

*Lipara rufitarsis** Loew, *L. similis** Schiner, *L. pullitarsis** Doskocil and Chvala, *L. lucens** Meigen (Diptera: Chloropidae)

The genus *Lipara* Meigen is restricted to the Palaearctic region, and all nine presently recognized species use *P. australis* as their sole host plant (Beschovski, 1984). The European species *L. lucens*, *L. rufitarsis*, *L. similis*, and *L. pullitarsis* cause more or less distinct apical shoot galls, in which the mature larvae overwinter (Chvala *et al.*, 1974). A single larva develops per shoot (De Bruyn, 1994). All four species are widely distributed through Europe with variable but usually low (5 to 10%) attack rates (Schwarzländer and Häfliger, 1999).

Sabrosky (1958) records 1931 as the first North American record of *L. lucens,* based on material from Connecticut. The same author reports intercepting *L. similis* in New York in a shipment from the Netherlands where dry *Phragmites* stems were used as packaging materials (Sabrosky, 1958). Use of

Phragmites as packaging material may be a major mode of introduction for many other insects that overwinter in dry stems of this species. Recent regional surveys in the northeast United States (Tewksbury *et al.,* 2002; Blossey and Eichiner, unpub.) reveal a widespread distribution and high abundance of *L. rufitarsis*, *L. similis* (Fig. 2), and *L. pullitarsis*. However, *L. lucens* has not been found after the initial record in 1931 and may not be established in North America. Taxonomic identification of adult flies is difficult and the species recorded in 1931 may have been misidentified and may have been *L. rufitarsis*. Attempts to locate the original specimens have been unsuccessful (Muth, pers. comm.). Attack rates in the northeastern United States, particularly of *L. similis*, can approach 80% (Balme, 2000; Blossey and Eichiner, unpub.).

Figure 2. Typical sign of attack of all *Lipara* spp. is the wilting of the top leaf. (Photograph by B. Blossey.)

The different *Lipara* species can be best distinguished using criteria of gall morphology and larval overwintering habit. Attack by *L. lucens* causes stunting of 10 to 13 internodes and larvae penetrate the growing point to feed in a gall chamber. Attack by *L. rufitarsis* causes stunting of only five to six internodes with larvae also penetrating the growing point. Attack by *L. pullitarsis* causes stunting of apical internodes and gall formation similar to *L. rufitarsis,* but larvae overwinter above the growing point. Attack by *L. similis* causes only slight alterations of shoot diameters. Similar to *L. pullitarsis*, *L. similis* larvae feed and overwinter above the growing point of attacked shoots. Attack by all *Lipara* species can easily be identified by dried up apical leaves and the lack of inflorescences on infested shoots. Pupation of larvae occurs in early spring and flies emerge in May.

Lasioptera hungarica Möhn (Diptera: Cecidomyiidae)*

Lasioptera hungarica is a univoltine gall midge with *P. australis* as the only recorded host plant (Skuhrava and Skuhravy, 1981). The species appears to be more common in eastern and southern Europe (Schwarzländer and Häfliger, 1999). Shoots infested by *L. hungarica* show no obvious signs of damage; however, they often break in strong winds at the site of attack, suggesting a weakening of stem tissues. Larvae overwinter in the stem, and 30 to 300 yellow-orange larvae often can be found in a single internode. The species is easily identified by its association with a black fungal mycelium (genus *Sporothrix*) (Skuhrava and Skuhravy, 1981) that fills the internode (Fig. 3). Oviposition by females also infects the stem with fungal spores, providing food for the developing larvae. *Lasioptera hungarica* was recognized in North America in 1999 (Tewksbury *et al.,* 2002) but the species is widespread throughout the northeastern United States (Blossey and Eichiner, unpub.).

Figure 3. Larvae of *Lasioptera hungarica*. Note the black mycelium of the associated fungus. (Photograph by P. Häfliger.)

Chaetococcus phragmitis Marchal (Homoptera: Pseudococcidae)*

The legless reed mealybug, *Chaetococcus phragmitis* (Fig. 4), has recently been found in Delaware, Maryland, New Jersey, southern New York (Kosztarab, 1996; Krause, 1996), Virginia and Connecticut (Blossey and Eichiner, unpub.), and Rhode Island (Tewksbury *et al.*, 2002). Native to central Europe, Armenia, Azerbaijan, and the Mediterranean region (Ben-Dov, 1994), this mealybug is only known to feed on *Phragmites* and *Arundo* species (Kosztarab, 1996). In North America, *C. phragmitis* is regionally very common (Krause, 1996). The mealybugs feed and overwinter under leaf sheaths.

Figure 4. Overwintering *Chaetococcus phragmites* under leaf sheaths of the host plant (partially removed). (Photograph by B. Blossey.)

Rhizedra lutosa (Hübner) (Lepidoptera: Noctuidae)*

The rhizome feeding noctuid moth *Rhizedra lutosa* (Fig. 5) was first reported in 1988 from New Jersey (McCabe and Schweitzer, 1991). It was subsequently found in the Catskills in New York in 1991 (Mikkola and Lafontaine, 1994) and by 1999 was widespread in Rhode Island, Connecticut, Massachusetts, New York, and as far west as Ohio (Tewksbury *et al.*, 2002). This moth overwinters as eggs deposited on *Phragmites* leaves. Larvae hatch in spring, enter newly growing *Phragmites* shoots, and feed in the rhizome. Attack by larvae results in shoot death, visible as dying yellow shoots in the middle of the growing season. Larvae complete development by July or August and pupate in the soil; adults fly in the fall. Attack rates appear low (Balme, 2000) and further work is needed to assess the potential of this species as a biological control agent.

Figure 5. Adult *Rhizedra lutosa* moth. (Photograph by P. Häfliger.)

Archanara geminipuncta (Haworth) (Lepidoptera: Noctuidae)

This shoot-boring moth has been extensively researched in Europe because of the damage it does to reed beds. Larvae mine the shoots in spring and early summer; adults fly in the summer and eggs overwinter. Mined portions of shoots and the growing point wilt after attack. A single larva needs several shoots to complete development, and attack rates of more than 50% of stems are common. Attack by this shoot-boring moth can reduce shoot height by 50 to 60% and result in significant reed dieback.

Phragmataecia castaneae (Hübner) (Lepidoptera: Cossidae)

This large moth needs two years to complete its development, which occurs at the base of the shoot and in the rhizomes. Moths fly in summer and females lay 200 to 400 eggs. Larvae may move from shoot to shoot as they look for new food during their development. Larvae can be found in both dry reed stands and those that are permanently flooded.

Chilo phragmitella (Hübner) (Lepidoptera: Pyralidae)

Like *P. castaneae*, this species mines shoots and roots of *Phragmites*. Larvae are active in the summer; older larvae mine deeper parts of the rhizome and are difficult to detect. Infested shoots remain small and wilt.

Schoenobius gigantella (Denis and Schiffermüller) (Lepidoptera: Pyralidae)

Larvae of this moth mine shoots of flooded *Phragmites* below the water level, causing considerable damage. Attacked shoots wilt and break apart. Little is known about the life history of the species, but it is assumed that larvae need two years to complete development. Adults fly in the summer.

Platycephala planifrons (Fabricius) (Diptera: Chloropidae)

Platycephala planifrons (Fig. 6) attacks *Phragmites* shoots early in the year leading to severe stunting of attacked stems by killing the growing point. *Platycephala planifrons* was one of the most damaging species found during surveys in Europe. Attack can cause biomass reductions of >50%. Females fly in the summer and are long lived. Eggs are laid in late summer. Larvae hatch in late summer, feed for a limited period, and overwinter.

Figure 6. Adult *Platycephala planifrons* fly on *P. australis* stem. (Photograph by P. Häfliger.)

EVALUATION OF PROJECT OUTCOMES

Establishment and Spread of Agents

No deliberate introductions of biological control agents have been made. The diversity of accidentally introduced *Phragmites* herbivores is highest closest to New York City (Blossey and Eichiner, unpub.). This suggests that a major area for the introduction of arthropods is the harbor. Various introduced species associated with *Phragmites* appear to be spreading from New York City along highways, rivers, and the coastline.

Suppression of Target Weed

No work on evaluating the effects of these European herbivores on *Phragmites* has yet been done in North America. However, the recent discovery of several such species in the northeast provides an opportunity to measure the influence of these organisms on *Phragmites* performance.

RECOMMENDATIONS FOR FUTURE WORK

Genetic analysis (Saltonstall, 2002) has confirmed the presence of native North American genotypes of *P. australis*. Promising biological control agents have been identified in Europe and their impact and host specificity need to be determined experimentally. Native North American genotypes of *P. australis* do exist, therefore it will be extremely important to assess whether the potential control agents show any preferences among different genotypes. The fact that some native North American herbivores appear restricted to native *P. australis* genotypes and that some accidentally introduced European insect herbivores do not attack native North American genotypes

(Blossey, unpub. data) is some indication that genotype-specific biological control may be possible. However, detailed investigations as to preference and performance of potential biological control agents on native North American and introduced European genotypes have to be conducted.

A large number of European herbivorous insects that are specific to *P. australis* have become accidentally established in North America. Some of these insects species are widespread and abundant in the northeastern United States. However, we do not know their full distribution, habitat requirements, or potential control value. In particular, gall flies in the genus *Lipara* and the rhizome-feeding moth *R. lutosa* are widespread, although only the *Lipara* species reach high abundances. These observations should form the basis for a more intensive analysis of the ecology and impact of these species and their potential to control the spread or reduce existing invasive populations of *P. australis*. It needs to be determined why *R. lutosa* does not build up to higher population levels and whether the attack by the gall flies or *R. lutosa* can stop the spread of *Phragmites* or weaken existing stands. Before any of these species may be used as biological control agents, their host specificity or impact on native *P. australis* must be determined.

We plan to establish a web-based system to collect information from land managers about the distribution of the various reed insects already present and spreading within the United States. The web site will feature pictures and drawings of the accidentally introduced insects and their feeding damage. For most of these organisms, their gross appearance or damage is distinctive, allowing non-entomologists to participate in data collection. This system will allow the production of distribution maps, and potentially will be able to track the spread of these organisms across the continent.

REFERENCES

Balme, G. R. 2000. Insects on *Phragmites australis*. M. S. thesis, University of Rhode Island, Kingston, Rhode Island, USA.

Ben-Dov, Y. 1994. *A Systematic Catalogue of the Mealybugs of the World (Homoptera: Coccoidea: Pseudococcidae and Putoidae) with Data on Geographical Distribution, Host Plants, Biology and Economic Importance*. Intercept Ltd. Andover, United Kingdom.

Benoit, L. K. and R. A. Askins. 1999. Impact of the spread of *Phragmites* on the distribution of birds in Connecticut marshes. *Wetlands* 19: 194-208.

Beschovski, V. L. 1984. A zoogeographic review of Palaearctic genera of Chloropidae (Diptera) in view of origin and formation. *Acta Zoologica Bulgarica* 24: 3-26.

Besitka, M. A. R. 1996. An ecological and historical study of *Phragmites australis* along the Atlantic Coast. M. S. thesis, Drexel University, Philadelphia, Pennsylvania, USA.

Chambers, R. M. 1997. Porewater chemistry associated with *Phragmites* and *Spartina* in a Connecticut tidal marsh. *Wetlands* 17: 360-367.

Chambers, R. M., L. A. Meyerson, and K. Saltonstall. 1999. Expansion of *Phragmites australis* into tidal wetlands of North America. *Aquatic Botany* 64: 261-273.

Chvala, M., J. Doskocil, J. H. Mook, and V. Pokorny. 1974. The genus *Lipara* Meigen (Diptera, Chloropidae); systematics, morphology, behaviour, and ecology. *Tijdschrift voor Entomologie* 117: 1-25.

Clayton, W. D. 1967. Studies in the *Gramineae*: XIV. *Kew Bulletin* 21: 111-117.

Darlington, C. D. and A. P. Wylie. 1955. *Chromosome Atlas of Flowering Plants.* George Allen and Unwin Ltd., London.

De Bruyn, L. 1994. Lifecycle strategies in a guild of dipteran gallformers on the common reed, pp. 259-281. *In* Williams, M. (ed.). *Plant-Galls: Organisms, Interactions, Populations*. Claredon Press, Oxford, United Kingdom.

Gagné, R. J. 1989. *The Plant-Feeding Gall Midges of North America*. Cornell University Press, Ithaca, New York, USA.

Gleason, H. A. and A. Cronquist. 1991. *Manual of Vascular Plants of the Northeastern United States and adjacent Canada,* 2nd ed. The New York Botanical Garden, New York.

Gochfeld, M. and J. Burger. 1997. *Butterflies of New Jersey*. Rutgers University Press, New Brunswick, New Jersey, USA.

Haslam, S. M. 1972. Biological flora of the British Isles, no. 128. *Phragmites communis Trinidad Journal of Ecology* 60: 585-610.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Herberger. 1977. *The World's Worst Weeds: Distribution and Biology.* The University Press of Hawaii, Honolulu, Hawaii, USA.

Jamison, K. 1994. Rx for Delaware's northern wetlands. *Outdoor Delaware* Fall, 1994, 4-9.

Kosztarab, M. 1996. *Scale insects of Northeastern North America.* Special Publication Number 3. Virginia Museum of Natural History, , Martinsville, Virginia, USA.

Krause, L. H. 1996. Terrestrial insects associated with *Lythrum salicaria*, *Phragmites australis*, and *Typha angustifolia* in a Hudson River Tidal Marsh. M. S. thesis, State University of New York, New Paltz, New York, USA.

Marks, M., B. Lapin, and J. Randall. 1994. *Phragmites australis* (*P. communis*): Threats, management, and monitoring. *Natural Areas Journal* 14: 285-294.

McCabe, T. L. and D. F. Schweitzer. 1991. *Rhizedra lutosa* (Lepidoptera: Noctuidae) newly introduced to North America. *Entomological News* 102: 130-132.

Metzler, K., and R. Rosza. 1987. Additional notes on the tidal wetlands of the Connecticut River. *Newsletter of the Connecticut Botanical Society* 15: 1-6.

Meyerson, L. A., K. Saltonstall, L. Windham, E. Kiviat, and S. Findlay. 2000. A comparison of *Phragmites australis* in freshwater and brackish marsh environments in North America. *Wetlands Ecology and Management* 8: 89-103.

Mikkola, K. and J. D. Lafontaine. 1994. Recent introductions of riparian noctuid moths from the Palaearctic region to North America, with the first report of *Apamea unanimis* (Hübner) (Noctuidae: Amphipyrinae). *Journal of the Lepidopterist Society* 48: 121-127.

Orson, R. A. 1999. A paleoecological assessment of *Phragmites australis* in New England tidal marshes: changes in plant community structure during the last few millenia. *Biological Invasions* 1: 149-158.

Sabrosky, C. W. 1958. A *Phragmites* gall-maker new to North America (Diptera, Chloropidae). *Proceedings of the Entomological Society of Washington* 60: 231.

Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of *Phragmites australis* into North America. *Proceedings of the National Academy of Sciences, USA* 99(4): 2445-2449.

Schwarzländer, M. and P. Häfliger. 1999. Evaluating the potential for biological control of *Phragmites australis* (Cav.) Trin. ex Steudel. Annual Report. CABI Bioscience Centre Switzerland, Delémont, Switzerland.

Skuhrava, M. and Skuhravy, V. 1981. Die Gallmücken (Cecidomyiidae, Diptera) des Schilfes (*Phragmites communis* Trin.). *Academia Praha, Studie Csav* 3: 1-150.

Tewksbury, L., R. Casagrande, B. Blossey, P. Häfliger, and M. Schwarzländer. 2002. Potential for Biological Control of *Phragmites australis* in North America. *Biological Control* 23: 191-212.

Thompson, D. J. and J. M. Shay. 1989. First-year response of a *Phragmites* marsh community to seasonal burning. *Canadian Journal of Botany* 67: 1448-1455.

Troubridge, J. T., S. M. Fitzpatrick, and J. D. Lafontaine. 1992. *Apamea ophiogramma* (Esper), a Palearctic cutworm new to North America (Lepidoptera:Noctuidae). *Canadian Entomologist* 124: 109-112.

Tscharntke, T. 1992. Fragmentation of *Phragmites* habitats, minimum viable population size, habitat suitability, and local extinction of moths, midges, flies, aphids, and birds. *Conservation Biology* 6: 530-536.

Tucker, G. C. 1990. The genera of Arundinoidea (Gramineae) in the southeastern United States. *Journal of the Arnold Arboretum* 71: 14-171.

U.S. Department of Agriculture. 1999. Reviewer's manual for the Technical Advisory Group for Biological Control Agents of Weeds. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Manuals Unit of Plant Protection and Quarantine. Annapolis, Maryland, USA.

Wapshere, A. J. 1989. A testing sequence for reducing rejection of potential biological control agents of weeds. *Annals of Applied Biology* 114: 515-526.