

**First-year Regrowth of Three Marsh Plant Communities  
After Fall and Spring Fires  
in the Delta Marsh, Manitoba.**

by

Jason Andrew Greenall

A thesis presented to the University of Manitoba in partial fulfillment of the requirements  
for the Master of Science degree in the Faculty of Graduate Studies

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AFTER FALL AND SPRING FIRES IN THE DELTA MARSH, MANITOBA

BY

JASON ANDREW GREENALL

**A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba  
in partial fulfillment of the requirements of the degree of**

MASTER OF SCIENCE

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## ABSTRACT

This study examined the effects of fall (1990) and spring (1991) burns on neighbouring marsh plant communities dominated by *Typha x glauca*, *Phragmites australis*, or *Scolochloa festucacea* in the Delta Marsh, Manitoba. The focus was on plant regrowth in the first post-burn season.

Two study plots 25 m x 25 m were laid out in areas where *Typha*, *Phragmites*, or *Scolochloa* had previously been dominant in fall-burned, spring-burned and unburned sites. Within these plots, subplots were randomly selected and the regrowth, in terms of shoot height, density, flowering, and aboveground biomass of the dominant species was monitored. The composition and aboveground biomass of the understorey was also monitored. In all plots, the position of the water table was determined and soil samples collected for moisture, organic, conductivity and pH measurements. Temperature and humidity were recorded from May to August in fall-burned and unburned *Phragmites* stands.

In *Typha* communities, regrowth began earliest in plots that had been burned, but by the end of the season unburned plots produced the tallest shoots. Mean shoot density was significantly higher in fall-burned plots (108 shoots·m<sup>-2</sup>) than in other plots, which had densities of approximately 55 shoots·m<sup>-2</sup>. Aboveground biomass of *Typha* was lowest after fall burning, intermediate in spring burned plots and highest in unburned plots. Mean biomass of *Typha* shoots was 6.5 g·shoot<sup>-1</sup> in fall-burned plots, compared with 13 to 16 g·shoot<sup>-1</sup> in the other plots. Understorey species were sparse in *Typha* study plots, and were a small component of the total community biomass. Significant differences in water levels were observed between burn treatments.

In *Phragmites* communities, regrowth also began earlier in burned plots than in unburned plots. Mean shoot density in fall-burned plots (126 and 139 shoots·m<sup>-2</sup>) was significantly higher than in unburned plots with 50 shoots·m<sup>-2</sup>, or in spring-burned plots

with 80 shoots $\cdot$ m<sup>-2</sup>. Aboveground biomass was also higher after both fall and spring burns than in unburned plots. Fall-burned plots had lower species richness and understorey biomass than either spring-burned or unburned plots. Both fall-burned and spring-burned *Phragmites* communities exhibited increased production over unburned areas. Significant differences in water levels, both within and between burn treatments, appeared to affect a number of regrowth parameters in this community.

In *Scolochloa* communities, there were no significant differences between burn treatments because there was significant variability within the fall-burned treatment for all measured vegetation parameters. However, *Scolochloa* shoot density was higher in spring-burned plots than in fall-burned plots, which tended to have shoot densities similar to unburned plots, but produced smaller shoots. Spring-burned plots had higher mean aboveground biomass (860 g $\cdot$ m<sup>-2</sup>) than unburned plots with 750 g $\cdot$ m<sup>-2</sup>. Mean biomass in fall-burned plots ranged from 300 to 815 g $\cdot$ m<sup>-2</sup>. Both fall and spring burning led to increases in the mean species richness and aboveground biomass of understorey species. High soil conductivity in fall-burned plots appeared to affect the vegetation, with poor performance of *Scolochloa* and high abundance *Atriplex patula*.

Vegetation regrowth in the three communities did not occur in a consistent or predictable manner.

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# CHAPTER 1

## INTRODUCTION AND LITERATURE REVIEW

On October 13-14, 1990 and April 12-14, 1991, accidental fires occurred in two areas of the Delta Marsh. The burned sites were separated by the Assiniboine River Diversion, a distance of approximately 400 m. Each fire burned approximately 250 hectares, and encompassed a number of marsh plant communities, dominated by *Typha x glauca* Godr., *Phragmites australis* (Cav.) Trin., or *Scolochloa festucacea* (Willd.) Link<sup>1</sup>. The timing of the burns provided an opportunity to examine first-year regrowth of these plant communities after two different burn treatments, and compare them with unburned sites. Most research into the effects of fire on wetland plant communities has focused upon only one plant community, or examines only one season of burning. The advantage of this study was the opportunity to simultaneously study the regrowth in three different plant communities after both fall and spring burns in a natural experiment (Diamond 1986).

The objective of this study was to determine the effects of fall and spring burning on regrowth of plant communities dominated by *Typha glauca*, *Phragmites australis*, or *Scolochloa festucacea* in the first post-fire growing season. The remainder of Chapter 1 is a review of the literature pertaining to the three plant communities and to the effects of fire on them. Chapter 2 describes the study site, Delta Marsh, and the burned areas being examined. The methods used for monitoring regrowth follow in Chapter 3. Chapter 4 presents the results of the study, and in Chapter 5 these are discussed and compared with other research.

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<sup>1</sup> Nomenclature follows Scoggan (1978). See Appendix 1 for complete nomenclature of plants encountered.

## **1.1 HISTORY OF FIRE IN PRAIRIE WETLANDS**

Historical evidence indicates that fire was once a common occurrence across the prairies. Ward (1968) cites accounts from the 1800's which describe fires stretching for hundreds of miles across the Red River plains, while Kantrud (1986) lists a number of accounts which specifically mention fires burning through prairie wetlands. Lightning is often responsible for starting wildfires (Wright and Bailey 1982; Thompson and Shay 1989; Kirkman and Sharitz 1994), as are humans. Aboriginal peoples once set fires intentionally both as signals and to improve success of bison hunting (Ward 1968). The arrival of European settlers in North America generally led to an era of fire suppression in many habitats (Wright and Bailey 1982).

The importance of fire as a disturbance which has shaped the natural vegetation of North America was recognized early in this century (Vogl 1967). Since that time, many researchers have examined the effects of prescribed burning on wetland vegetation for management purposes. Early studies were largely qualitative in nature, aimed at improving wildlife habitat by suppressing growth of dominant species (Vogl 1967, Schlichtemeier 1967, Ward 1968). Recently, researchers have also become interested in the effects of fire on community composition (Thompson and Shay 1989, Schmalzer et al. 1991, Cowie et al. 1992, Kirkman and Sharitz 1994), due in part to a desire to increase or maintain diversity in wetland habitats (Kirkman and Sharitz 1994). As well, there is an interest in examining how alterations in wetland disturbance regimes may affect vegetation (Mallik and Wein 1986, Turner 1987). However, despite increased interest in wetland communities as a whole, emphasis has remained on dominant wetland species because of the influence they have on other species, both before and after fire.

## 1.2 ECOLOGY OF THE DOMINANT SPECIES

Plants in prairie wetlands are positioned along a water depth gradient indicative of their tolerances to flooding (Kantrud et al. 1989). The dominant species in the three plant communities studied, *Typha glauca*, *Phragmites australis* and *Scolochloa festucacea*, are no exception. *Typha glauca* can survive in up to 100 cm of standing water (Waters and Shay 1990), but can also perform well in drawdown sites (Shay and Shay 1986). *Phragmites australis* can withstand prolonged flooding to a depth of 50 cm and drawdown to a depth of 100 cm (Shay and Shay 1986). While *Scolochloa festucacea* shares similar water depth tolerances to those of *P. australis*, it generally requires a seasonal drawdown to survive. Stands of *S. festucacea* are killed when continuously flooded from May to October (Neckles et al. 1985). Because each of these species is capable of growing under drawdown conditions, it appears that flooding episodes have determined the locations of each plant community by selectively killing species not adapted to particular water depths. Thus *T. glauca* and *P. australis* are generally found at lower elevations than *S. festucacea* because these sites would have undergone deeper and more prolonged flooding than *S. festucacea* could tolerate at some time in the past.

Each of the three species are herbaceous perennials which spread by rhizomes (Scoggan 1978). The rhizomes have a number of buds which may elongate to produce aboveground shoots. The largest buds are found at the apex of the rhizome, and may chemically suppress elongation of smaller lateral buds through apical dominance (Thompson 1982). Bud size determines basal diameter of shoots, which is in turn positively correlated with shoot height (van der Toorn and Mook 1982; Haslam 1970). Apical buds are therefore capable of producing larger shoots than lateral buds.

Once established, these species grow vegetatively and form monodominant stands, capable of suppressing invasion by other species and eliminating other species already



present (van der Valk and Davis 1980). They exhibit characteristics which make them excellent competitors, such as large storage organs, a height advantage over other species in the community, the ability to spread laterally both above and below ground, high growth rate, and the ability to respond rapidly to stress and disturbance (Grime 1979). The combined effects of these characteristics allows a high rate of resource acquisition in crowded and productive vegetation, and rapid adjustment to changes in the growing environment. These species are therefore able to outcompete the other species found in their understorey. The process by which this competition occurs is described by Keddy (1989) as competitive dominance, whereby one species suppresses another through exploitation and/or interference competition. First, the dominant species is able to lower the resources available to the subordinate, while using the resources it has exploited to produce more growth, further lowering resources available to the subordinate species. Second, the dominant species can interfere with subordinates, leaving more resources available to the dominant to increase its interference over them.

Among the most important features that the dominant plant species in this study possess is their ability to produce large amounts of biomass. Below ground level, the high density of rhizomes produced by the dominant species interferes with the establishment of other species, and allows the dominant species to exploit resources at the expense of other species. Above ground level, high productivity allows greater exploitation of light by shading the understorey species. Furthermore, the slow decomposition of this biomass, typical of wet environments, results in large buildups of plant litter and standing dead material, which may persist for several years before being decomposed. In *Phragmites australis* communities, the mass of dead plant material may be greater than the mass of living canes (Thompson and Shay 1985). Eventually, the buildup of plant material can also have shading and crowding effects on the dominant species themselves, as they must expend larger amounts of stored reserves in spring before shoots can emerge from the litter and begin to undergo photosynthesis (Graneli 1989).

Accumulations of dead plant material by the dominant marsh species significantly reduce understorey species richness and abundance (Thompson and Shay 1989). Litter buildups may inhibit seedling establishment in several ways (van der Valk 1986). Mats of plant litter may be so thick that they prevent seeds from reaching the soil surface after their dispersal. If seeds do reach the surface, they may be inhibited from germinating. Many seeds require intense light, or fluctuations in temperature to germinate, both of which are reduced by the shade the plant litter produces. If seeds successfully germinate, shade may inhibit seedling growth sufficiently to cause their death. Allelopathy has also been mentioned as a possible factor in the inhibition of seed germination in wetlands, through a release of compounds found in dead plant material. McNaughton (1968) reported an allelopathic effect using *Typha latifolia* L. leaf extracts, but these results could not be duplicated by other researchers (Grace 1983).

### **1.3 THE ROLE OF DISTURBANCE IN WETLANDS**

#### **Fluctuating water levels**

In prairie wetlands, periodic disturbance is an important process in renewing species and habitat diversity by reducing the dominance of a small number of species (van der Valk 1981). The most important type of natural disturbance in these systems is fluctuating water levels. Cycles of flooding and drawdown normally occur every 5 to 20 years (van der Valk and Davis 1980) as a result of unstable precipitation patterns (Adams 1988). Prolonged flooding may kill all emergent vegetation, and the subsequent drawdown provides an opportunity for seed germination on exposed mudflats (van der Valk 1981). Species colonizing mudflats may include the former dominants, as well as a number of ruderal species adapted to exploiting disturbed environments. Ruderals are generally annuals or short-lived perennials which complete their reproductive cycles rapidly

before being eliminated by another change in the growing environment (Grime 1979). A return to normal water levels will eliminate species which are unable to tolerate the new growing conditions, and over time, a number of highly competitive species become dominant, eliminating other species through modifications to their environment (van der Valk and Davis 1980). A period of prolonged flooding is then required to renew this cycle of vegetation change.

## **Fire**

In some respects, fire is analogous to a period of flooding followed by drawdown, in that both may kill off vegetation and expose the soil surface, providing a substrate and suitable conditions for seed germination. However, while prolonged flooding may result in the elimination of entire plant communities, fire rarely does. Kantrud (1986) states that little change in marsh community composition occurs when perennials with meristems at or below ground level are burned in the dormant season. Even summer burning is unable to eradicate all species (Thompson and Shay 1989). Regrowth of surviving species and invasion by new species after fire is, therefore, more difficult to predict than the colonization after flooding and drawdown (Smith and Kadlec 1985b).

### **1.4 EFFECTS OF FIRE ON WETLAND PLANT COMMUNITIES**

Differences in vegetation regrowth between spring and fall burns are due not only to the direct effects of burning, but also to the indirect effects that result from the complex interactions of fire with the environment. The direct effects of burning are the combustion of fuel and the production of heat and ash. Thompson and Shay (1985) reported temperatures of 250 to 500 °C at the soil surface when burning *Phragmites australis*. However, Wright and Bailey (1982) state that for the type of fuels found in marshes, temperatures below the soil surface generally do not exceed 80°C, do not rise appreciably

beyond a depth of 10 mm, and do not persist for more than two to four minutes. Under these conditions, temperatures should have little effect on soil organic matter, microbial populations, or buried seeds (Wright and Bailey 1982). It thus seems unlikely that high temperatures are responsible for all burn effects.

There are many potential indirect effects attributable to environmental changes that may play a role in vegetation regrowth following fire. Most of these changes may be traced back to the removal of plant material by fire. Burning removes the insulating layer of plant litter on the soil surface (van der Valk 1986). This is especially important in the fall. While litter has insulation value, it also causes snow to accumulate, which helps to prevent frost damage to rhizomes. Thompson and Shay (1985) found that fall-burned stands of *P. australis* accumulated one third as much snow as unburned stands, making fall-burned stands susceptible to earlier and deeper ground frosts. In contrast, spring-burned and unburned stands are insulated by plant litter and deeper snow cover, which protects them from frost damage. Spring fires remove the insulating layer of plant litter, but by that time temperatures are often mild enough that frost damage to rhizomes is unlikely.

The effects of litter removal on soil temperature continue to be important in the early part of the growing season. The soil surface in burned areas warms more rapidly than in unburned areas because it is not being shaded by plant litter, and because fire leaves behind a blackened surface (Smith 1973). The dark surface absorbs more radiant solar energy than unburned areas covered with reflective plant material, resulting in higher soil and water temperatures in early spring (Diirro 1982). In early spring, fall-burned sites may be warmer than spring-burned sites because the reduced accumulations of snow melt faster and expose the soil surface earlier to the warming effects of the sun.

Litter removal and its influence on microclimate may play an important role in determining the water levels found within different treatments, especially fall burns. Reduced snow accumulation after fall burns leads to decreased spring runoff (Kantrud et

al. 1989). Spring-burned sites may accumulate as much snow as unburned areas, but they are influenced by environmental changes brought about by burning such as more rapid warming of the soil surface.

Combustion of aboveground biomass can have several effects on soil properties, and in turn, on the vegetation growing after fire. Fire essentially consumes organic matter, usually a slow process of litter decomposition (Wright and Bailey 1982). Fire results in the deposition of partially burned plant material and ash on the soil surface. Partially burned plant material may be incorporated into the soil after fire, resulting in increased soil organic matter (Schmalzer and Hinkle 1992). Alternatively, decreases in soil organic matter have been observed after burning due to increased rates of biological activity by soil fauna (Wright and Bailey 1982). The ash contains a number of basic cations (Ca, Mg and K), and anions (phosphates, sulphates, oxides and carbonates) left behind after organic molecules are oxidized. These ions may be available for immediate uptake by plants, or incorporation into the soil. If incorporated into the soil, the additional ions increase soil electrical conductivity (Schmalzer and Hinkle 1992). Basic cations found in the ash generally increase soil pH after burning (Schmalzer and Hinkle 1992). Rivard and Woodard (1989) found that addition of *Typha latifolia* ash increased the pH of leaf extract solutions by 2-3 pH units.

Removal of plant litter is a key factor in the vegetation changes which occur after burning. Burning provides understorey species with the opportunity to become established in previously unsuitable sites (van der Valk 1986). Removal of litter exposes the soil surface to bright sunlight, so that at the beginning of the first post-fire growing season, soils warm more rapidly and provide favourable conditions for seed bank germination, resulting in increased species diversity (Thompson and Shay 1989). The increased light intensity can also have profound effects on the dominant marsh species. Thompson and Shay (1985) state that tillering of these species increases with light intensity at the soil

surface, resulting in higher shoot densities. Thus, litter removal by fire may be able to stimulate growth of a more diverse and productive habitat.

Experiments dealing with the effects of fire on marsh vegetation have been conducted in many areas. Mallik and Wein (1986) studied seasonal burning and flooding treatments in a brackish New Brunswick marsh. Smith and Kadlec (1985a,b,c) examined various effects of burning in a Great Salt Lake marsh. The effects of burning on *Phragmites australis* have been documented in the U. K. (Cowie et al. 1992) and in the Netherlands (van der Toorn and Mook 1982, Mook and van der Toorn 1982). Turner (1987, 1988) performed a burn study in a *Spartina alterniflora* Loisel. marsh in Georgia. Fall burning of *Spartina bakeri* Merr. and *Juncus roemerianus* Scheele marshes in Florida was studied intensively (Schmalzer et al. 1991, Schmalzer and Hinkle 1992, 1993). However, many of these studies were performed where climate, salinity, hydrology, and species composition differed from the prairies, making comparison with prairie marshes difficult. The number of burn studies in prairie wetlands is small, but will be the focus where possible of the following review of the effects of fire on wetland vegetation.

Fire is often used in an attempt to reduce density of *Typha* spp., with results varying from ineffective to very successful (Kantrud 1986). Mallik and Wein (1986) found that *Typha* spp. cover, shoot density, height, and basal diameter all increased following spring, summer, and autumn burns in areas flooded to a 50 cm depth, but decreased following similar fires in drained areas. Ball (1990) reported that winter burning followed by spring flooding of *Typha* spp. in Ontario resulted in reduced shoot density and shoot height, as well as a complete lack of flowering shoots. Where burning and flooding left no dead standing shoots above the water, oxygen could not reach the rhizomes via the air spaces in leaves, and rhizomes were killed. If, however, even a small part of a plant remained above water, sufficient oxygen could reach the rhizomes to allow some shoots to emerge and grow.