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Influence of Subsequent Flooding Depth on Cattail Control by Burning and Mowing

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ABSTRACT

This study experimentally compares 2 techniques which mimic natural phenomena and are thus potentially both acceptable to the public and useful for controlling cattail (*Typha* spp.) in areas where wildlife is a major concern. In a marsh in southwestern Ontario, 40 plots were burned or mowed over ice in early spring and subsequently flooded. Regrowth was assessed at the end of the growing season. The cutting rates of 3 mowing implements (tractor-drawn rotary mower, self-propelled sicklebar and brush cutter) over ice were 0.38, 0.07 and 0.05 ha per hr respectively. If flooding was deep, both burning and mowing treatments killed cattail equally well and in such cases fire would be less expensive. Quite unexpectedly however, there was a strong interaction between technique and flooding depth; in shallow water, mowing suppressed the regrowth of cattail much more than fire.

Key words: Typha spp., management, wildlife, habitat, fire.

INTRODUCTION

Cattails (*Typha* spp.) are a group of aquatic macrophytes that have caused serious weed problems throughout the world. In some situations, a control method can be chosen simply on the basis of cost-effectiveness, but in other situations additional factors can be more important. For example, cattail marshes are so important to wildlife that the public or special interest groups may effectively limit the available options for managing vegetation. Specifically, techniques such as dredging or herbicide application may be beyond consideration because of concern over these artificial forms of management, whereas management techniques that mimic natural processes may be readily accepted by the public for use in those areas where wildlife is a prime concern.

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In fact, the improvement of habitat for wildlife is usually the very reason for even considering cattail control within a marsh. Cattails can be beneficial to wildlife, but many marshes attract few waterbirds or other wildlife because cattails grow in such extensive stands that almost all open water is eliminated (Nelson and Dietz 1966). Many species of wetland wildlife favour marshes where a 50:50 ratio of cattail to open water is achieved by patches of open water about 0.15 ha in size set in a matrix of emergent vegetation (Weller 1975, Kaminski and Prince 1981, Murkin et al. 1982, Ball 1989). There have been numerous attempts to improve marshes for wildlife by removing cattail from selected areas to achieve this configuration (see reviews in Linde 1969, Beule 1979), but few were conducted with regard to mimicking natural processes, and few were experimental.

Fire is a natural perturbation in many marshes, either as the result of lightning, or, more recently, of fires set by aboriginal peoples (Ward 1968). Fire followed by flooding may open up stands of some species of macrophytes (Ward 1968, Lynch 1941), but studies of the effects of fire on cattail have yielded conflicting results. These discrepancies probably have resulted from comparing areas burned by fires of varying intensity, or from comparing the effects of fire in marshes differing in many aspects (e.g. soil, hydrologic regime, etc.).

Mowing simulates the cutting of cattail by a large population of muskrats (*Ondatra zibethicus*) and is thus also a "natural" form of management. Cattail may be indirectly managed by manipulating muskrat numbers, but mowing followed by flooding yields more immediate results and does allow more precise control. There have been numerous attempts to control cattail by mowing during the growing season (see reviews in Weller 1975, Beule 1979, Sale and Wetzel 1983), but cattail control at this time is expensive because of the slow rates of movement by machinery over soft substrates. Discing over ice before the growing season can control cattail (Murkin and Ward 1980), but, at least on dry land, discing is much slower than rotary mowing. Estimates of cattail mowing rates are important to managers for selecting equipment and for forecasting expenditures of time and money, but most published reports of cattail mowing rates are for equipment moving through mud during the growing season. Thus, one objective of this study was to provide estimates of the mowing rates of different implements over ice. I evaluated a tractor-drawn rotary mower, a self-propelled sicklebar and a brush cutter.

Many studies have assessed a single technique for controlling cattail (e.g. mowing, herbicide use), but even studies evaluating a particular procedure often have yielded conflicting conclusions. This lack of agreement may be attributable to differences in the length of the growing season among studies, the genetic constitution of the cattail populations in different areas (Bedish 1967), or simply differences in weather. To eliminate these confounding variables and provide a better basis for choosing a control technique, the various techniques need to be studied on a single cattail population in the same growing season. A second objective of this study was to compare the efficiency of killing cattail by the "natural" techniques of mowing and burning. A considerable advantage of this comparative approach over previous studies is that it permits testing for an interaction between technique and subsequent flooding depth (i.e. if mowing and burning differ with water depth).

MATERIAL AND METHODS

The study was conducted at the St. Clair National Wildlife Area, a 243 ha diked marsh with water level control, on the shore of Lake St. Clair in southwestern Ontario. The growing season is 208 days, mean July and January temperatures are 22 and -4C respectively, and the annual precipitation is 76 cm (McKeating et al. 1982). Soils are Rego Humic Gleysols (Bayly 1975) and the principal vegetation is cattail (*Typha* spp.). Although both *T. angustifolia* L. and *T. latifolia* L. are present, *T. glauca* Godron is dominant (Bayly 1975).

Burning or mowing treatments were randomly assigned; 21 and 19 circular plots averaging 0.09 ha were mowed and burned, respectively. A firebreak was first cut around plots to be burned and then a flamethrower was used to burn the standing cattail within the plots. The flamethrower used propane from standard 9 kg tanks mounted on a backpack frame. This combination proved mobile, although fuel lasted for less than an hour. Burning began shortly after dawn, but fires were of low intensity until the sun melted the frost on the cattail. Winds were $<$ 20 km per hour, and the temperature was near freezing. Because the flamethrower could produce such a large flame (1.8 m), the main fires (set with the wind) could be controlled by quickly lighting backfires (against the wind) when necessary.

Cattail was mowed over the frozen substrate with: 1) a rear-mounted rotary mower 1.5 m wide powered by a 65 horsepower tractor, 2) a self-propelled sicklebar mower (5 horsepower, 0.8 m wide), and 3) a brush cutter. The self-propelled sicklebar resembled a roto-tiller with a cutterbar in place of tines. The brush cutter resembled a string trimmer used to edge lawns but had a larger engine and was fitted with a 3-tooth blade 23 cm in diameter. Cattail debris from the mowing was left on the ice.

Unlike many previous studies, in this study basin topography permitted comparing the effects of mowing and burning on the same population of cattail subsequently flooded to a range of water depths (20 to 80 cm). Flooding was completed before the growing season (early April) and stable water levels were maintained by pumping until after the growing season (mid-September) to eliminate the confounding effects of water level fluctuations.

Many species of wildlife use only the edges of a cattail stand because they are physically excluded from the interior by the dense vegetation. Therefore, shoot density was chosen as the single most relevant assessment of the effects of the burning and mowing treatments. Cattail shoot density and height, as well as numbers of fruiting heads, were assessed at the end of the growing season by randomly placing 0.5 m^2 quadrats within each burned or mowed plot and at randomly selected control sites where the cattail was not removed but was subjected to identical flooding. It is important to note that the data analysis included only those quadrats where the burning and mowing treatments were "complete" (i.e. all cattail shoots were cut or burned short enough to be entirely submerged after flooding). Therefore, the comparisons of burning and mowing in this study were not confounded by variations in the application of the experimental treatments (e.g. variable fire intensity, mower malfunctions).

The effects of treatment and water depth on height and shoot density were analyzed using Analysis of Variance followed by Fisher's protected LSD multiple comparison procedure, and indicator variable regression (Steel and Torrie 1980). Data were $\log_{10}$ transformed where required to satisfy the assumptions of parametric tests (Steel and Torrie 1980). Data are presented below as $\pm$ 1 standard deviation.

RESULTS

Mowing rates (ha per hr) were 0.38 for the rotary mower, 0.07 for the self-propelled sicklebar, and 0.05 for the brush cutter. Mowing rates for the self-propelled sicklebar and the brush cutter were influenced much more by cattail density and operator fatigue than the tractor-drawn rotary mower was.

The rotary mower left about 16 cm of stubble over the substrate whereas the sicklebars and the brush cutters left about 5 cm of stubble. Because the rotary mower was mounted on the rear of the tractor, some cattail was flattened by the tires and not cut by the subsequent passage of the mower. Some of these uncut shoots projected above the water after flooding.

The fires advanced through the cattail between 1 and 8 km per hour depending on cattail density and wind speed. Flame heights averaged about 2m but sometimes exceeded 6 m. In areas where fire intensity was low, some cattail shoots were visible above the surface of the water after flooding.

There were no significant differences in shoot density, shoot height or fruiting head production between any of the cutting treatments ($p > 0.60$), so all cutting treatments were pooled. Burning ($n = 70$ total quadrats) reduced shoot density 70% relative to controls ($n = 52$, $p < 0.001$, indicator variable regression) but mowing ($n = 77$) resulted in even more of a reduction (89%) than burning ($p < 0.001$, indicator variable regression). Most importantly, there was a strong interaction between treatment and water depth ($p < 0.001$, Figure 1). In shallow water mowing was much superior to burning for killing cattail, but if flooding was deep there was no significant difference between them.

Cattail plants that survived burning were shorter at the end of the growing season (2.71 m ± 0.27) than controls (2.89 m ± 0.20, $p < 0.001$), but plants that survived mowing were even shorter (2.48 m ± 0.35, $p < 0.001$). No fruiting heads were produced in areas subjected to mowing or burning but did occur in 13% of 52 control quadrats in 1982 and in 24% of 46 control quadrats in 1983. No germination was detected at any site.

Because some cattail survived both treatments, some plots were randomly selected to evaluate the effects of retreatment during the subsequent winter. However, regrowth was too sparse to carry a fire, so only mowing treatments could be repeated. Plots mowed once had 89% fewer shoots than controls, but plots mowed twice had 99% fewer (only 0.3 ± 1.4 shoots m^{-2} on average). The few plants that survived mowing in 2 successive winters were shorter (2.29 m ± 0.39) than controls (2.89 m ± 0.20, $p < 0.001$).

DISCUSSION

Cattail size is correlated with both sexual and vegetative reproduction (Grace and Wetzel 1981a, 1981b, 1981c, Sale and Wetzel 1983). Cattails thus allocate reserves from rhizomes to fruiting head production (sexual reproduction) and increases in shoot number and height (vegetative reproduction). In this study, rhizomes were not sampled to investigate changes in reserves, but both sexual and vegetative reproduction declined after both treatments. Therefore, it appears that the declines in shoot height, shoot density and fruiting head production were not artifacts of temporary resource re-allocation, but were accurate reflections of control, because the areas of open water resulting from the treatments persisted for at least 3 years.

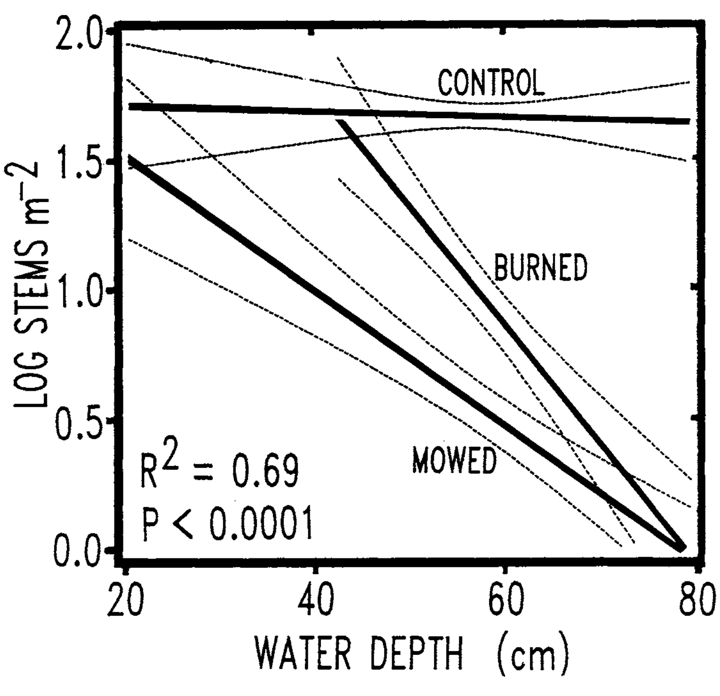

Figure 1. The relationship (with 95 % confidence limits) between fall cattail (*Typha* spp.) shoot density ($\log_{10}$ number of shoots per m), treatment, and water depth at the St. Clair National Wildlife Area, southwestern Ontario. All 3 regressions differ significantly from each other ($p < 0.001$).

In the fall, the aerial shoots of cattail die but remain standing. During the winter, aerenchyma in these shoots conduct oxygen to the submerged rhizomes, which require some oxygen even though they are dormant (Sale and Wetzel 1983). In spring, when the plant begins to grow, its oxygen demand increases substantially. If the aerial shoots are cut or burned off and submerged, the supply of atmospheric oxygen is eliminated and the growing plant is limited to the supply in its rhizome (Murkin and Ward 1980). When oxygen concentrations in the rhizomes reach zero (in about 8 hours), ethanol is produced by anaerobic respiration (Sale and Wetzel 1983). If new shoots do not reach the surface before tissue breakdown proceeds too far, the plant dies. Only those quadrats where treatment was complete were included in the analysis, because even a small part of a shoot above the surface is sufficient to maintain a high oxygen concentration in the rhizome (Sale and Wetzel 1983).

Marsh fires can sometimes kill vegetation directly by consuming rhizomes (Lynch 1941), but in this study they were protected by the frozen substrate. Therefore, mortality in both burned and mowed treatments was presumably the result of the subsequent spring flooding cutting off oxygen transport to the rhizomes by covering the stubble. Previous studies have not tested for any interaction of treatment with water depth, nor might one expect any if only the removal of oxygen was involved. Surprisingly however, cattail mortality did differ between mowed and burned areas depending on water depth. If flooding was shallow, mowing resulted in greater mortality than burning, but if flooding was deep the 2 treatments were not significantly different (Figure 1). Clearly some additional factor must be involved. Mowed areas (regardless of mowing implement) had a thick layer (about 35 cm) of cattail debris over the substrate whereas burned areas had very little. This layer of chopped cattail may have physically prevented shoots from reaching the surface, or it may have reduced regeneration by shading the growing shoots. Buele (1979) demonstrated that shading reduced regeneration of cut cattail although his plants were not submerged.

Clearly then, if subsequent flooding will be deep, fire would be a good choice to control cattail because the results in deep water are the same as mowing, yet burning would normally cost less. The main difficulty in burning is in controlling and directing the fire, but if fires are conducted in winter, intensity is lower than in warmer months. In addition, ice allows faster movement of men and equipment to cut firebreaks and light backfires, so fires can be better directed than in summer.

I found that a slow-moving backfire left the shortest stubble and thus would require less of an increase in water level to submerge the shoots. However, fires did not burn down to the ice; instead some stubble was left (approximately 18 cm), possibly due to protection by steam in a vapor zone (Schlichtemeier 1967) or a high moisture content in the basal portions of the shoots. Snow buildup on the ice may result in even taller stubble and thus reduce the probability that water levels will cover the stubble. Burning in early winter before snow accumulation, or in early spring after the snow has melted, may solve this problem and still allow mobility on the ice.

If subsequent flooding is likely to be shallow, mowing would be a better choice than fire because it results in much greater cattail mortality (Figure 1). Of the 3 mowing implements, more shoots escaped cutting in areas mowed with the rear-mounted rotary mower than with other implements. This occurred because some cattail shoots were flattened by the tractor wheels and not cut by the subsequent passage of the mower. These shoots projected above the surface of the water after flooding and conducted oxygen to the rhizomes below, resulting in rows of cattail regrowth that were absent in areas cut with other implements. The self-propelled sicklebar and brush cutter are obviously more suited to small scale manipulations than the other methods considered here because of their relatively slow cutting rates (0.07 and 0.05 ha per hour, respectively). These 2 implements can, nevertheless, be used when ice is too thin to support any tractor, and they would also be very suitable for creating firebreaks before burning.

The tractor-drawn sicklebar (0.29 ha per hr) cut much faster than a tractor-drawn disc (Murkin and Ward 1980) but the rotary mower was fastest (0.38 ha per hr). On the basis of mowing rate alone, the rotary mower was superior. The best implement, however, may not have been evaluated in a published study yet: a tractor-powered side-mounted sicklebar. It is a very common farm implement, and, because it cuts to the side (rather than passing over cattail just flattened by the tires as the rotary mower does), the rows of regrowth left in areas cut with the rear-mounted rotary mower would not occur with a sicklebar. A second advantage of the sicklebar is that it cuts the cattail much closer to the ice than a rotary mower (5 vs 16 cm). This is an important advantage in marshes lacking water control because the rhizomes will be cut off from oxygen for a longer time if water levels decline. A third advantage of the sicklebar over a rotary mower is that a sicklebar can be used with a lighter, less powerful tractor because the sicklebar merely snips off the shoots whereas the rotary mower shreds them. A smaller tractor is less likely to break through the ice and is easier to get out when it does.

Kill of cattail is greatest when cut during its period of low carbohydrate reserve which occurs in the growing season (Beule 1979). Although this period does not coincide with the time when mowing over ice is possible, the high cutting rates (0.38 ha/hr) obtained in this study show that mowing over ice in early spring can still be cost-effective. Cattail management programs for the benefit of wetland wildlife have been severely limited because specialized equipment suited to the marsh has not been available (Beule 1979), or has simply been too expensive. However, mowing over ice can be performed by ordinary farm implements that otherwise sit idle during winter and thus might be rented from farmers at reasonable rates.

If a single treatment does not provide adequate cattail control, it appears that a second consecutive treatment probably will. In this study, 2 consecutive mowings resulted in a 99% reduction in shoot density relative to untreated areas (effectively producing areas of open water).

In summary, cattail control by mowing with brush cutters or self-propelled sickle bars would be useful only for cutting firebreaks or very small-scale work. A rotary mower over ice appears to be the most cost-effective method of mowing cattail yet reported, but, because of trampling problems, future workers should investigate the cutting rate of a tractor-powered side-mounted sicklebar. More importantly, this study shows that one must consider the interactive effects of water depth and cattail control method: mowing is preferable in shallow water, but burning is less expensive and performs just as well in deeper water.

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