Evaluating effect of cutting depths on regrowth of invasive cattails (*Typha angustifolia*)

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Abstract

Cattail (*Typha* spp.) expansions into wetlands can reduce open-water habitats and negatively affect native flora and fauna diversity. Cattail removal is needed to maintain wetland quality; however, removal is often non-permanent requiring repeated treatments to retard reestablishment. Cutting cattails with mechanical harvesters is a common management technique; however, it is unclear what cutting depths are optimal. We conducted a controlled, replicated experiment at Cheyenne Bottoms Wildlife Area (CBWA), Kansas, USA during 2017-2018 to address this question. We hypothesized cattails cut below water would have reduced gas exchange capabilities due to flooded aerenchyma resulting in greater mortality. We conducted genetic testing in CBWA and identified narrowleaf cattail (*Typha angustifolia*), which is considered an invasive species in Kansas. Within this stand of cattail, we established a randomized complete block design experiment with four blocks, and three clipping treatments in July 2017. Clipping treatments included a control (no cattails clipped), an above-water treatment (cattails cut 15 cm above water surface) and a below-water treatment (cattails cut 15 cm below water surface). We quantified emergent stem densities in each plot in September 2017 to assess the effectiveness of simulated management actions. Mean stem densities were greatest in the control (113.0±10.7 stems). Clipping the cattails resulted in significantly fewer stem counts in both the above-water cutting treatment (44.1±10.7, p=0.0032) and in the below-water cutting treatment blocks (11.1±12.5, p=0.0004). The BW treatment had fewer stems than the AW treatment, though not statistically significant (p=0.0789). Our experiment was inadvertently destroyed with herbicides in 2019 preventing further comparisons. This is the first known genetic-level confirmation of narrowleaf cattail at CBWA, which is a Ramsar Wetland of

International Importance. Our results suggest that management efforts focused on cutting cattails below water can reduce cattail growth.

Keywords: Cheyenne Bottoms Wildlife Area, *Typha angustifolia*, Wetland, Wetland Management

Introduction

Typha (hereafter 'cattail') species are widespread and occur in wetland ecosystems across Earth (Smith, 1987). Cattail expansions can elicit negative ecological responses including depression of native vegetation diversity and fauna occurrence (Kostecke et al. 2005; Tuchman et al. 2009). Removing cattails is often needed to restore habitat quality in affected wetlands (Bansal et al. 2019); however, removal is generally not permanent and repeated management regimes can be costly. Thus, effective management techniques are needed to restore and preserve wetland quality.

Managers use diverse techniques to remove cattails from affected wetlands with varying success. Examples include tillage (Kostecke et al. 2004), prescribed burning (Mallik and Wein 1986; Ball 1990; Kostecke et al. 2004; Ponzio et al. 2004), herbicide treatments (Lawrence et al. 2016), cattle grazing (Kostecke et al. 2004), draining (Mallik and Wein 1986), flooding (Mallik and Wein 1986; Ball 1990), and cutting by hand or mechanized means (Ball 1990; Hellsten et al. 1999; Lishawa et al. 2015, 2017, 2019; Johnson et al. 2019). Kostecke et al. (2004) found a combination of cutting, disking, and prescribed burns may provide only short-term benefits and may also have negative impacts to non-cattail vegetation. Some management techniques (e.g., disking, cattle grazing) require dry periods or human manipulation to draw water down, which is unrealistic in many wetlands. Cutting can be implemented in wetlands with varying water depths. However, limited information exists regarding effectiveness of this technique. Johnson et al. (2019) reported below-water cutting of invasive-hybrid cattails (*Typha x glauca*) by hand or through mechanized means may reduce biomass and increase nutrient availability in coastal Great Lakes wetlands. Lishawa et al. (2017) observed similar results with mechanized cutting of cattail below water in a different Great Lakes region wetland. It remains unclear if similar techniques result in reduced cattail biomass in managed emergent wetlands in the Great Plains. In addition, the relative effects of other cutting-related variables (e.g., depth of cutting relative to water level, removal of cut biomass, timing with respect to the growing season, tools used to cut cattail) are unknown. Further, while the effectiveness of cattail management using tillage, burning, and grazing has been explored in Kansas and the Great Plains region (Kostecke et al. 2004), we are not aware of other studies documenting the effectiveness of cutting cattail in that region.

Our objectives were to assess optimal cutting depths to setback cattail reestablishment in Cheyenne Bottoms Wildlife Area (CBWA), a “Wetland of International Importance” (Ramsar Convention on Wetlands, 2002) located in the south-central Great Plains in the USA. Because it was unclear what species of cattail occurred in CBWA, and specifically within our study plots, we also used genetic tools to confirm species identity. We tested if above-water or below-water cutting techniques performed by hand resulted in differing cattail reestablishment patterns. Because aerenchyma are vital for cattail root and rhizome respiration, we expected that flooding aerenchyma would reduce respiration capabilities resulting in greater cattail mortality rates. Thus, we predicted treatments with below-water cutting regimes would result in reduced future stem counts compared to treatments with above-water cutting regimes and controls.

Materials and Methods

We conducted our study in CBWA (38.3645ºN 98.7648ºW) in Kansas, USA. CBWA is in the south-central Great Plains and is a depressional wetland (~8,000 ha) occurring in the largest interior wetland in the USA (~16,000 ha). Because of its importance to waterfowl and waterbird migration in North America, CBWA is designated as a "Wetland of International Importance" (Ramsar Convention on Wetlands, 2002). CBWA undergoes extensive moist-soil management efforts to improve habitat quality for migrating waterfowl, and thus enhance waterfowl hunting opportunities. We established our experiment in a centrally located pool in CBWA where water is stored and used to flood outer pools. This location had stable water depths (approximately 90 cm), an established cattail population, and was protected from physical disturbances from waterfowl hunters. The 30-year average annual temperature is 12.4ºC and precipitation is 693 mm as measured at the Great Bend 3WNW weather station (Applied Climate Information System, 2022).

Prior to our study, it was unclear what cattail species occurred in CBWA. We collected stem samples from our study plots for genetic conformation of species identification. To determine the species of each stem, microsatellite genotyping was conducted using five species-diagnostic loci described in Snow et al. (2010), including *TA*3, *TA*7, *TA*8, *TA*16, and *TA*20. DNA was extracted from leaf tissue using a DNeasy Plant Mini-kit (Qiagen, Inc., Valencia, CA) according to the manufacturer's protocol. PCR amplifications of each of the five species-diagnostic loci were conducted according to the methods described in Tsyusko-Omeltchenko *et al.* (2003). We resolved microsatellite alleles by capillary electrophoresis at the Keck Biotechnology Resource Laboratory (Yale University, New Haven CT), and sized using Genemapper, Version 3.7. Based on genotyping results, a sample was classified as either pure *T. angustifolia* or *T. latifolia* if all alleles were diagnostic of one or the other species, or as hybrid *T. x glauca* if it exhibited a blend of alleles.

We used a randomized complete block design, which included four blocks with three plots (one control and two treatments) per block. Each plot was 2 m x 2 m and separated from adjacent plots by a 1-m wide alley (cattails cut 20 m below the surface) for researchers to move freely between plots. Each of the four blocks were established with the inside edge of the first plot occurring 10 m from the dyke surrounding the pool, and the outside edge of the third plot occurring at 19 m from the dyke. Each block was separated by a 1 m alley so that gaps between plots were identical between plots both within a block and between blocks. In July 2017, we imposed one of three randomly assigned cutting treatments on each set of three plots including an uncut control (C), cutting cattail 20 cm above the water surface (AW), and cutting cattail 20 cm below the water surface (BW). Stems were cut by researchers (CJM and AAA) using hand-held shears. Our treatments were imposed in July when warm soil temperatures result in higher respiration and oxygen consumption rates, increasing the likelihood of cattail root and rhizome death following cutting. No stem counts were performed at the time treatments were imposed. We conducted emergent stem counts for cattail and phragmites (*Phragmites australis*) within each plot in October 2017, and noted whether stems were new or regrowth of previously cut stems. Only stems with green growth were counted, not dead stalks. Two researchers (CJM and AAA) counted every plot. No significant difference was observed between researchers, so we used the average plot-specific stem counts for subsequent analyses. We attempted to repeat stem counts in 2018; however, our experimental setup was inadvertently sprayed with herbicides by managers of CBWA to control newly emerged *Phragmites australis* plants.

We investigated differences in average stem counts from October 2017 between treatments, plot location, and blocks using a standard least squares model and a Tukey highest significant difference test to compare means. All analyses were conducted using JMP Pro 14 (SAS Institute Inc., Cary, NC, 1989-2019) and we established an *a priori* cutoff of $p \leq 0.05$ for statistical significance.

Results

Genotyping identified all sampled stems as invasive narrowleaf cattail (*Typha angustifolia*) at four of five microsatellite loci, with slight ambiguity at a fifth locus (*TA*7) due to the presence of an allele not reported in Snow et al. (2010). The latter allele size placed it in an intermediate position relative to size ranges reported for *T. latifolia* (native broadleaf cattail) and *T. angustifolia*. Given the unequivocal assignment of all other alleles at this and all other typed loci to *T. angustifolia*, it is likely this was a heretofore unreported *T. angustifolia* allele. Based on overlapping multi-locus genotypes, we found that stem sampling captured three distinct *T. angustifolia* clones (genets).

There was no difference in average total cattail stem counts between blocks ($p = 0.3257$) or plot location ($p = 0.0574$), though cutting treatment was significant ($p = 0.0004$, Fig. 1). The W treatment had the fewest mean stem counts (9.4 ± 5.3), followed by the BW treatment (47.6 ± 5.7) and control (111.3 ± 5.3). The AW treatment had significantly fewer total stems than both the C ($p = 0.0003$) and the BW treatments ($p = 0.0203$). The AW treatment also had significantly fewer stems than the C treatment ($p = 0.0032$). Between three and 11 stems that regrew from previously-cut stems were observed in the AW treatment, but no stem regrowth was observed in the BW treatment (Fig. 1). Phragmites stems were observed in two plots from separate blocks, including 12 stems in one C treatment plot, and nine stems in one AW treatment plot.

Discussion

Wetland managers need effective tools to setback encroachment and establishment of cattails to increase wetland habitat quality for native flora and fauna. Cutting cattails can be an effective tool if cattails are cut at depths that minimize regrowth times. Our results concur with Johnson et al. (2019), as we found cutting cattails reduced average emergent cattail stem counts, especially when cutting below water. In addition, our results indicated below-water cutting of stems suppresses regrowth of previously cut cattail stems. To our knowledge and that of the site manager (J. Wagner, personal communication), our study represents the first genetic-level identification of *T. angustifolia* at CBWA and future work should quantify the relative distributions of *T. angustifolia*, *T. latifolia*, and *T. x glauca* occurring on this wetland of international importance and surrounding wetlands in Kansas.

Although we did not observe significant differences in stem counts between blocks, the within-block distribution of treatments may have affected cattail regrowth and underscores a potential caveat with our study. Shading effects from surrounding cattail, or cattails growing in nearby control plots may have influenced cattail regrowth in adjacent treatment blocks. Future experimental investigations should use larger plots distributed in areas with minimal shade coverage to eliminate the potential for shading effects. Due to our experiment being inadvertently terminated early due to spraying phragmites, we were not able to quantify the persistence of the treatment effects. However, Johnson et al. (2019) noted reduced regrowth in cattails 1-year post cutting by hand, and it is likely we would have observed similar patterns if our experiment continued.

We conclude that cutting cattail is an effective mechanical control to cattail establishment and encroachment, and that cutting cattail stems below the water surface is more effective than cutting above the water surface and the uncut control. Further investigation is necessary to determine practices that maximize cattail suppression as influenced by timing of cutting, position of cuts relative to the water surface and/or root collar, duration of ponding above stem cuts, and cattail species. In addition, future research should investigate the establishment of desirable wetland plant species and use by wildlife following cattail cutting.

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Figure

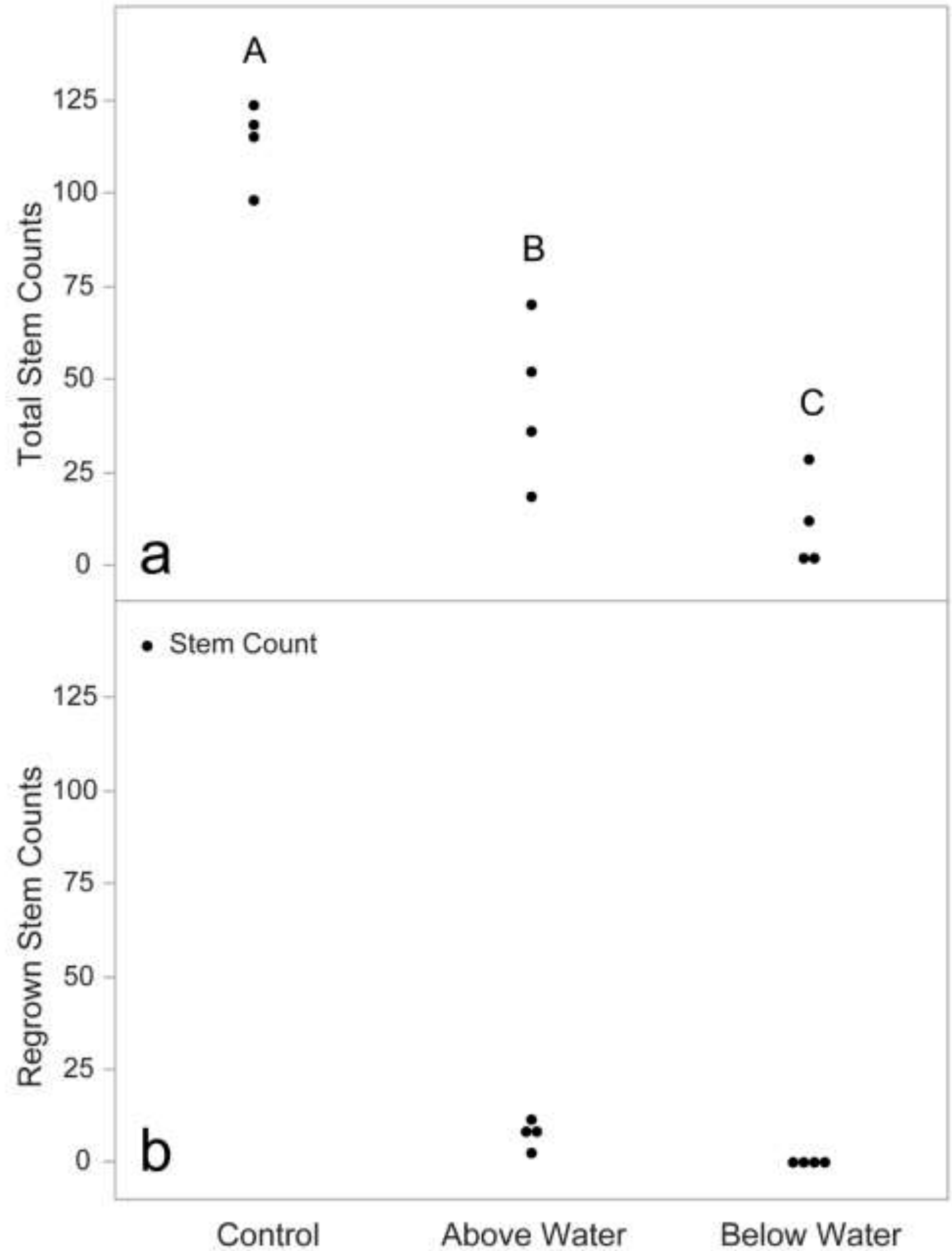

Figure 1. Average total stem counts (a) and average regrown stem counts (b) for the control, cut above water, and cut below water treatments. Significant differences ($\alpha = 0.05$) in total stem counts between treatments are indicated by different capitalized letters. Regrowth of stems were not determined in the C treatment.