Final Report
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Illinois Wildlife Preservation Fund - Large Project

Project Title: Monitoring the effect of disturbance on the growth and development of planted giant cane to improve success of canebrake restoration.

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Summary

This is the final project report presented to the Office of Resource Conservation of the Illinois Department of Natural Resources detailing methods and results of the project and providing recommendations for culturing planted giant cane for the restoration of canebreak habitat.

Introduction and Project Justification

Giant cane (*Arundinaria gigantea* (Walter) Muhl.) is member of the *Bambusoidae* division of the grass family *Poaceae* (Simon 1986). This riparian species once formed extensive stands or "canebrakes" throughout the southeastern United States (Marsh 1977). However, land conversion for agricultural purposes, overgrazing, and fire suppression have greatly reduced the abundance, frequency, and extensiveness of these unique ecosystems. Consequently, canebrakes are now considered a critically endangered ecosystem (Platt and Brantley 1997, Bell 2000, Platt and others 2001). Giant cane is a target species designated by The Nature Conservancy in the upper east coast priority area. Canebrake habitat enhancement is a goal of the members of the Cache River Wetlands Joint Venture Partnership which include The Nature Conservancy, Illinois Department of Natural Resources, the Cypress Creek National Wildlife Refuge of the U.S. Fish and Wildlife Service, Ducks Unlimited, and Citizens Committee to Save the Cache River. Further, the Illinois Wildlife Action Plan recognizes the canebrakes as a "Priority Natural Community" for restoration in the Cache and Wabash watersheds.

Canebrake riparian zones enhance water quality. The dense stands of giant cane form dense mats of culms and rhizomes that stabilize streambanks and promote water infiltration (Schoonover and others 2002, Schoonover and Williard 2003, Schoonover and others in press). Canebrake habitat is also important for wildlife (see Table 1; Platt and others 2001, Schoonover and Helms 2005). Giant cane stands are crucial nesting habitats for birds, most notably the rare Swainson's Warbler (*Limnothlypis swainsonii*) and endangered (likely extinct) Bachman's warbler (*Verivora bachmanii*) (Remsen 1986, Thomas and others 1996). Consequently, there is great interest in giant cane restoration within the region.

Giant cane can be propagated sexually, but seed is sporadically produced and has low viability (Farrelly 1984, Platt and Brantley 1997). Once established, this species primarily spreads by underground rhizomes. Giant cane can be asexually propagated by digging and transplanting culms or culm offsetting. However, this method is labor intensive, cumbersome, and costly (Platt and Brantley 1993). Canebrake restoration efforts have been limited by a lack of available planting stock and practical methods of propagating the species (Feeback and Luken 1992). Moreover, there is a paucity of knowledge of how to practically establish field plantings and coax them to spread rapidly into extensive stands. Thus, it is crucial to understand factors that enhance the propagation, growth, and development of this species in order to judiciously and effectively use the limited resources available for habitat restoration success.

We have demonstrated practical methods for propagating giant cane through rhizome cuttings. We previously established field plantings, through a cooperative venture on land owned by The Nature Conservancy (Rose Farms, Belknap, IL) and managed by Southern Illinois University (SIUC) and Cypress Creek National Wildlife Refuge. Survival and spread of re-established giant cane had been monitored for four growing seasons depending on the site (Zaczek and others 2004a, b). Thus far, growth and spread of surviving cane plants on these sites have been steady, but relatively slow, especially on sites with competing vegetation.

These four-year old established cane sites present an opportunity to evaluate management practices that could enhance the establishment, competitive position, growth, and spread of the species. We tested treatments (fire and fertilization) and their interaction to determine necessary management activities needed to promote the successful development of canebreak habitat.

Project Objectives

Our overall objective is to improve management techniques to enhance the growth, spread, and competitive position of planted giant cane for the development of canebrake ecosystem habitat. We utilized an existing 4 year-old planting of cane to apply and compare 4 ecologically and operationally appropriate management techniques and measure the growth response of the cane. We will perform the following:

1. Determine the impact of fire alone on planted giant cane, as fire is a natural force that giant cane has evolved with and should be well adapted to in the development of cane communities.
2. Determine the impact of fertilization on the growth and development of giant cane to enhance nutrient availability needed for growth and development.
3. Determine the impact of fire and fertilization in combination on management plots containing planted giant cane.
4. Quantify growth and spread of giant cane under ambient conditions, in the absence of nutrient or fire management.

Methods

The study was conducted within a cane planting that was originally established using plant material dug from a nearby natural stand in 2001 on land owned by The Nature Conservancy (TNC). This bottomland agricultural site was recently in row crop production. The site was purchased by TNC with the intention of restoring the land to native plant species. Planting stock included large rhizome pieces and culms with the distal ends partially exposed to light as recommended by Zaczek et al. (2004a, b). The planting consisted of two parallel rows of cane in raised beds, each approximately 1 m wide by 350 m long (east to west) and 2 m apart with a ~25 cm deep trench in between rows. At the onset of the study, besides giant cane, the study site vegetation was primarily a mixture of annual and perennial grasses and forbs with scattered seedlings and saplings of light-seeded tree species.

In early 2005, John Hartleb and Jim Zaczek established 40 experimental plots (14 m long with a 3 m buffer in between neighboring plots -) in the 2 parallel rows (20 in each row). Plots were located by randomly choosing a sampling point at 1 m increments along the experimental plot length (down the center of each planted row). If that point did not contain cane then a new point was chosen within the experimental plot until cane was present in sample plot. A wire stake flag was inserted in the center of the sample plot and the distance from the south edge of the experimental plot to the sample plot were recorded for each sample plot and a sampling square (1 m on each side) constructed of PVC pipe was set on the ground. Two ~2.5 x 2.5 cm by 25 cm long stakes were pounded into the ground at diagonal corners so the same sample plot could be relocated later.

Fertilizer was randomly applied to 10 plots within each block on May 25 in 2005 (year 1) (Figure 1). We used a granular 12-12-12 N:P:K mix and applied it at a rate of 56.1 kg/ha actual nitrogen. Plots were fertilized again on March 24, 2006.

A considerable increase in cane and other vegetation growth and vegetative fuels occurred in the 2005 growing season requiring a modification in fire treatment. Prescribed fire could not safely be applied to individual experimental plots without risking the chance of fire escaping into plots targeted as fire controls (no fire application) because of a considerable amount of vegetation and fuels in the plots and their close proximity to each other. To minimize this risk, the site was divided into a north and south block and fire treatments (fire or no fire) were randomly assigned to one contiguous half of each block (Figure 1). Buffer areas or fire lines were created for fuel reduction between fire treatments.
Fire lines or breaks were mowed in buffer areas between designated fire treatments just before application. Fire-treated plots were burned on Feb. 23, 2006 by volunteers from the Southern Illinois University, Saluki Fire Dawgs. After burning, most of the above-ground vegetation in the burned plots was consumed except for some isolated small patches within some plots

Measurements: Prior to all treatment applications (year 0), the number culm stems, the height (cm) and diameter (to the nearest 0.1 mm, 1 cm above the soil surface) of the tallest culm per plot (referred to as culm height and culm diameter, respectively), and the percentage cane canopy coverage (to the nearest 5%), and the distance from the south edge of the experimental plot were recorded on March 25 and April 5, 2005 from sample plots. To determine the outward or lateral spread of the cane, a series of second 1 m sq sample plot (called adjacent sample plots or adjacent plots) were located adjacent and abutting each central row sample plot. In the easternmost row, adjacent sample plots were located directly east of the central sample plots. In the westernmost row, the adjacent sample plots were located directly west of the central sample plots. At the initiation of this study, these adjacent plots generally had very few or no cane culms growing in them.

Plots were resampled (year 1 data) using the methods described above for height (cm) and diameter (mm) of the tallest culm in the plot, the number of culms, the percentage cover of the sample plot by cane on January 11, 2006 (year 1), and in February and March 2007 (year 2 data).

Figure 1. Assigned plot numbers and fertilization (F=Fertilized, NF=Not Fertilized) and fire treatments. Plots 1 to 5, 11 to 15, 21 to 25, and 31 to 35 were randomly chosen as being in the burn blocks and remaining plots were unburned.

South -------------> North

plot #	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
West Row	F	NF	NF	F	NF	NF	NF	F	F	NF	F	F	F	F	NF	NF	F	NF	NF	F

East Row	F	NF	F	NF	F	F	NF	F	F	NF	F	NF	NF	NF	F	NF	F	NF	NF	F
plot #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

We used the mixed model procedure in SAS (SAS Inc. 2003) to analyze giant cane responses to the management treatments according to a split plot design, with fire (two levels: burned after year one and reflected in year 2 data and unburned) as the whole plot treatment and fertilization (fertilized prior to years 1 and 2 and unfertilized) as the subplot treatment. We used the mixed model procedure so that we could (1) use Satterthwaite's method to estimate denominator degrees of freedom as recommended for designs with unequal replication of treatments and different error structure associated with unequal number of subplots and wholeplots, (2) assign block as a random effect, and (3) choose the most appropriate covariance structure for data with repeated measures over time (Littell et al. 1996). Because all treatments were not applied each year (i.e., no treatments in the pretreatment year and burning only in year 2), we used contrast statements to determine whether temporal changes in the vegetation occurred over time within a treatment combination and compare cane responses to treatment combinations within a year.

1) Did treated plots (either fire or fertilizer) differ in the measured characteristics from their respective controls prior to treatment (year 0)?
2) Did treated plots (either fire or fertilizer) differ in the measured characteristics from their respective controls after treatment?
3) Was there an interaction between fire and fertilization?
4) Did characters measured in control plots and treated plots differ from year to year (pretreatment, year 1, and year 2)?

Results

Prior to treatment, in main row sample plots, cane foliage was 44.1% of the vegetative canopy cover (Figure 2), the mean density of culms was 31.2 m^{-2} (Figure 3), mean height of the tallest culm was 126.4 cm (Figure 4), and the mean diameter of the tallest culm was 7.07 mm (Figure 5). In main row plots, there were no significant pretreatment differences among subplots assigned to all four fire x fertilizer treatment combinations. In the adjacent plots that were established to gage lateral spreading of the cane, there was relatively little cane presence and development at the onset of the study prior to treatment with a vegetative canopy cover mean of 5.2% (Figure 6), the mean density of culms was 4.3 m^{-2} (Figure 7), mean height of the tallest culm was 88.6 cm (Figure 8), and the mean diameter of the tallest culm was 5.10 mm (Figure 9). There were no pretreatment differences in adjacent plots for fertilized vs. unfertilized comparisons or for those designated to burn or remain unburned for percentage cover, culm density, and height. However, plots designated to be fertilized and unburned had a smaller mean diameter than the other treatments. This, in part may be due to the relatively undeveloped cane in adjacent plots and that at this time period only 62% of adjacent plots had cane in them.

Following one growing season, after the first application of fertilization treatments had been completed, the percent cover (+40% mean increase), culm density (+41%), height (+29%), and diameter (+29%) of the cane in most cases (13 of 16 cases) increased in the non-spread (main) plots (Figures 2, 3, 4, and 5) relative to pretreatment values. In year 1, there were no significant differences between the fertilized or unfertilized plots for any of the measured variables. Similar patterns among treatment and within year comparisons occurred in adjacent plots except that mean increases of percentage cover (+329 % mean increase), culm density (+319%), height (+59%), and diameter (+28%) were considerably greater than had occurred in main row plots. There were no differences among treatments for all measured variables in year 1 for adjacent (spread) plots.

After the second growing season, following one prescribed fire and two fertilizer treatments, there were differences in responses among the treatments, primarily driven by fire but also affected by fertilization in comparisons within a year and from year-to-year. Compared to unburned plots, fire tended to reduce percent cover, height, and diameter of culms in main plots (Figures 2, 4, and 5) to levels similar to year 1 or year 0 values. In adjacent spread plots, culms were also smaller in height and diameter in burned plots (Figures 8 and 9). However, prescribed burning resulted in greater density of cane culms compared to the unfertilized/unburned treatment in main row plots. Burning resulted in an even more dramatic increase, more than two-fold, in culm density in adjacent plots. In the absence of burning, fertilization increased percent cover and culm height in main row plots than other treatments

Figure 2. Average (± 1 SE) percent cover of giant cane in main row plots by treatment and over time. Difference among the treatment combinations within a year indicated by letters a-c; changes over time within a treatment combination indicated by letters x-z. Means accompanied by the same letter were not significantly different (α=0.05).

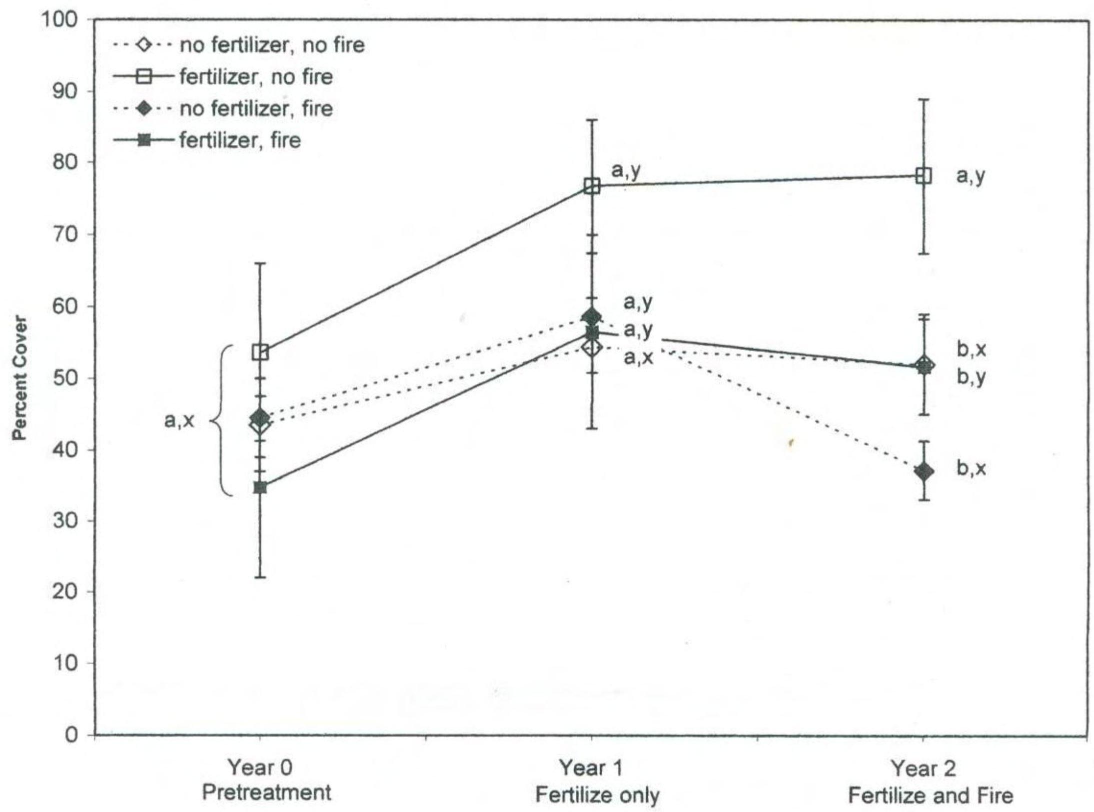


Figure 3. Average (± 1 SE) culm denisty of giant cane in main row plots by treatment and over time. Difference among the treatment combinations within a year indicated by letters a-c; changes over time within a treatment combination indicated by letters x-z. Means accompanied by the same letter were not significantly different (α=0.05).

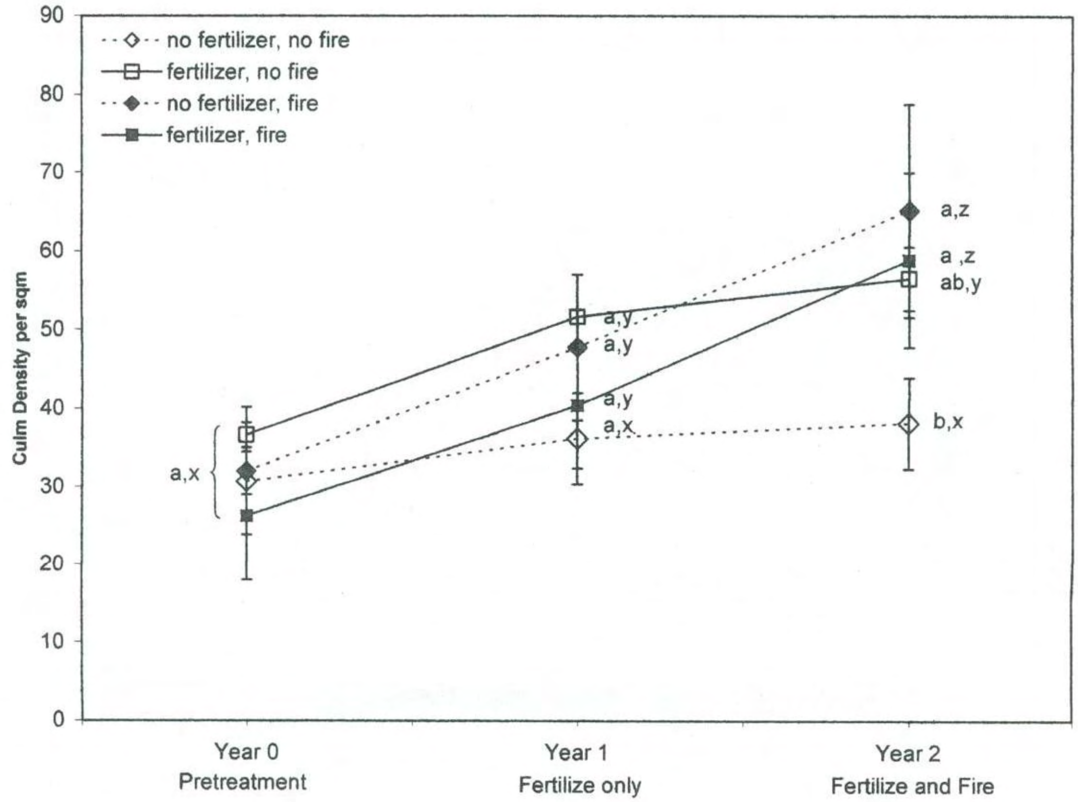


Figure 4. Average (± 1 SE) culm height (cm) of giant cane in main row plots by treatment and over time. Difference among the treatment combinations within a year indicated by letters a-c; changes over time within a treatment combination indicated by letters x-z. Means accompanied by the same letter were not significantly different (α=0.05).

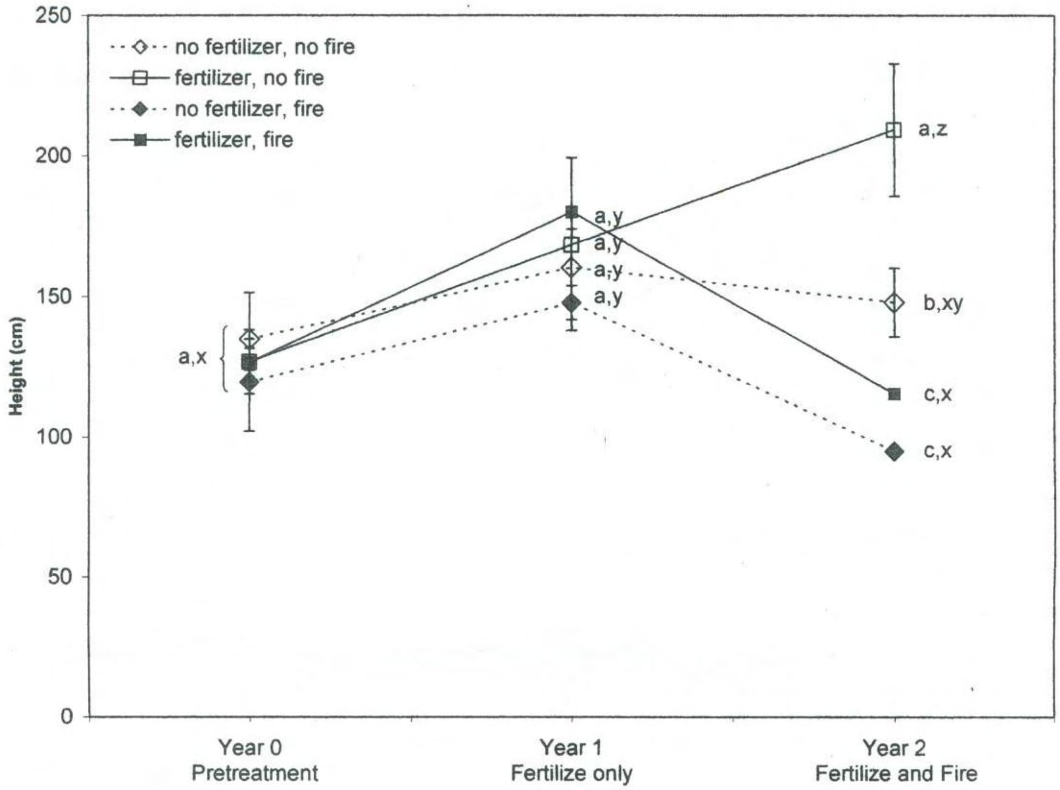


Figure 5. Average (± 1 SE) culm diameter (mm) of giant cane in main row plots by treatment and over time. Difference among the treatment combinations within a year indicated by letters a-c; changes over time within a treatment combination indicated by letters x-z. Means accompanied by the same letter were not significantly different (α=0.05).

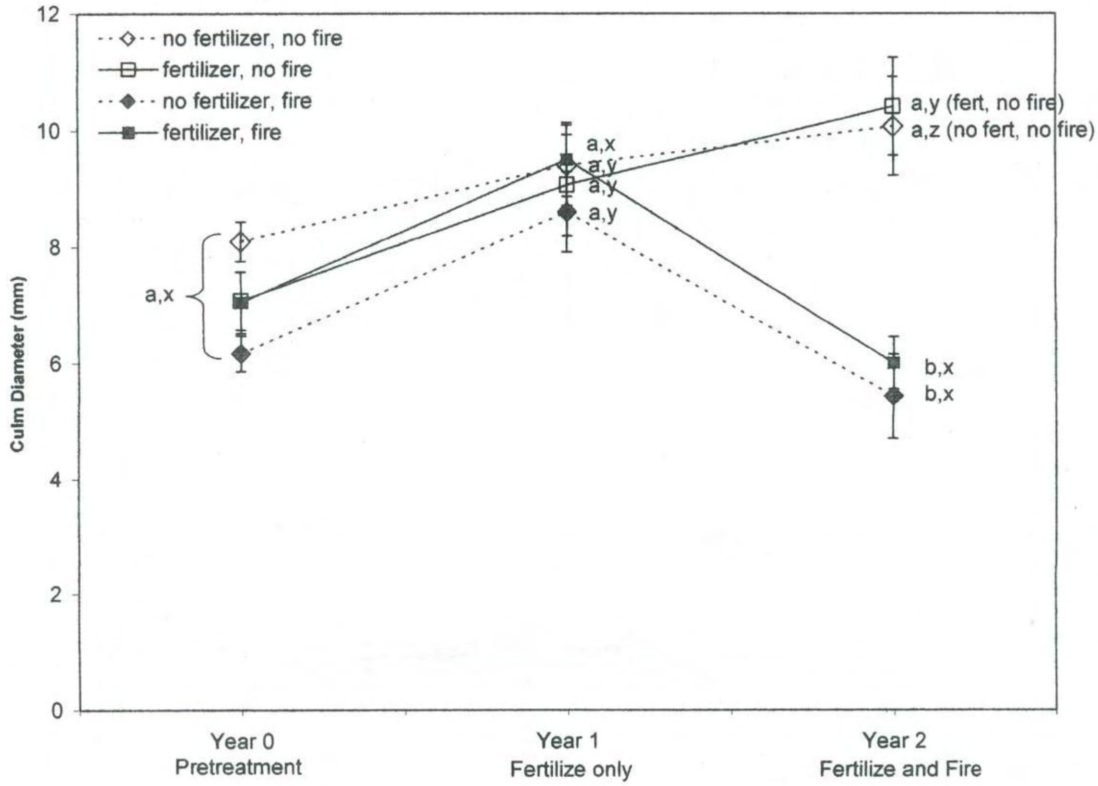
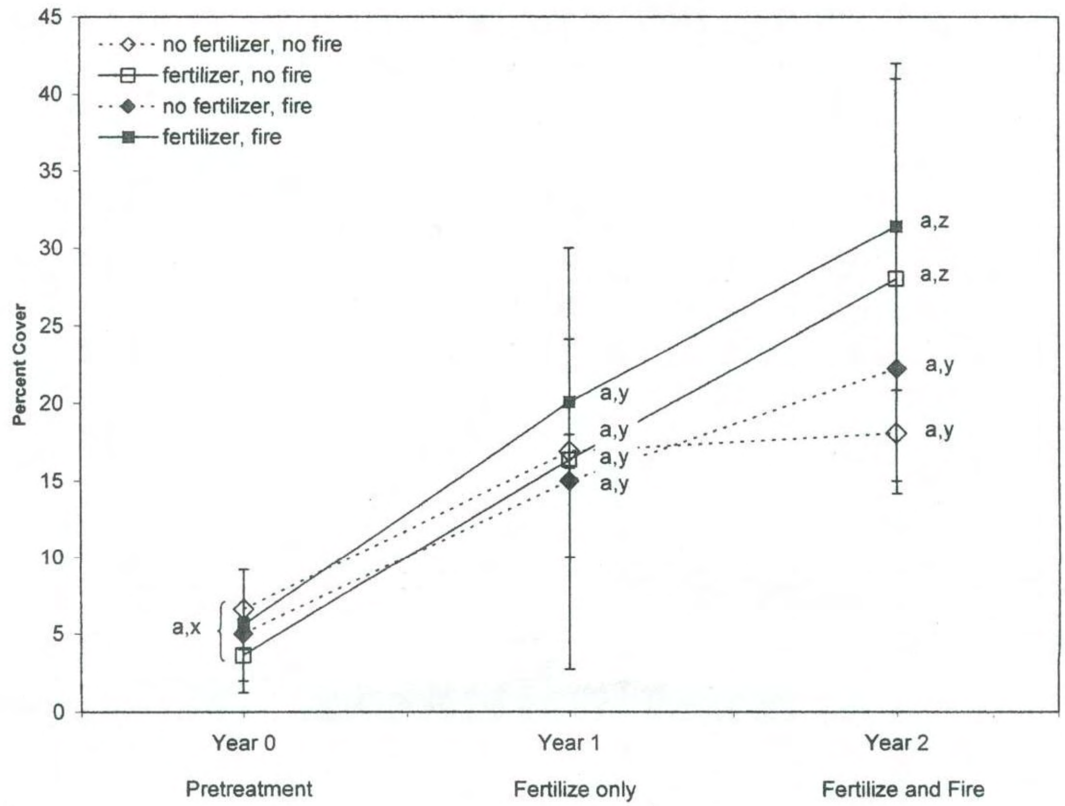


Figure 6. Average (± 1 SE) percent cover of giant cane in adjacent plots by treatment and over time. Difference among the treatment combinations within a year indicated by letters a-c; changes over time within a treatment combination indicated by letters x-z. Means accompanied by the same letter were not significantly different (α=0.05).



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Zaczek*, J. J. and J. L. Hartleb. 2006. Giant cane habitat restoration: ecology, propagation and canebrake establishment techniques. Illinois' Cache River--Advancing the Restoration of an Internationally Significant Wetland Ecosystem Symposium. National Great Rivers Research and Education Center and the Joint Venture Partnership for the Cache River Restoration. August 10-12, 2006, Carterville, IL.

Published abstracts:

Zaczek*, J. J., J. E. Schoonover, S. G. Baer, K. W. J. Williard, J. W. Groninger. 2007. Cultural methods and restoration ecology of giant cane (*Arundinaria gigantea*). *Abstract in* Proceedings of the North American Forest Ecology Workshop. June 18-20, 2007. Vancouver, British Columbia, Canada. p. 76

Additionally, we are currently preparing a manuscript detailing the study to be reviewed for publication in the journal *Restoration Ecology*. Furthermore, we have conducted and interview about giant cane in Illinois that is slated for publication in Outdoor Illinois. An undergraduate (David Dalzotto) in the Department of Forestry also conducted a 9 month research project through the SIUC Undergraduate REACH Award program.

Acknowledgements

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Conclusions and Recommendations

Giant cane restorations can be enhanced with fertilization and judicious use of prescribed burning. Fertilization increased growth and development parameters of giant cane significantly in some comparisons and somewhat but not significantly in other comparisons by the second season after repeated applications. Other work related to cane fertilization (Dalzotto and others, unpublished data) showed that soils from fertilized plots had similar and low levels of nitrogen as unfertilized plots. This suggests that cane readily sequesters available nitrogen into plant biomass reducing the likelihood of offsite leaching. This may also suggest that the amount of fertilizer used was below the optimal rate that could be utilized by the giant cane.

Prescribed burning reduced percentage cover one year after application, but increased the density of culms. We surmise that this effect of burning on culms will result in a delayed increase in cover due to the slow growth rate of cane. The negative effects of fire on cane cover were partially offset by fertilization in conjunction with burning. Stem density was substantially increased in areas that were in early developmental stages (adjacent plots). Although woody plant competition was limited at this site, it was noted that fire tended to reduce sapling presence in burned plots. Consequently, prescribed burning may be necessary to successfully establish giant cane stands with burgeoning woody plant competition. Additionally, fertilization prior to burning may help recovery and growth of the cane that develops after fire. However, without testing plantings of cane in response to fires at repeated intervals, managers must be prudent with the use of prescribed burning because overly frequent treatments may cause cane decline. Based on cane's mixed response to fire, with greater culm density but smaller culm size, and considering the planting was 5 years old at the time of burning, we suggest that the fire frequency should not be more frequent than five years. Furthermore, burning may not be necessary if competition is low from woody plants that may eventually overtop cane.

This research on effects of fire disturbance, fertilization, and the interaction of those factors provides resource managers and researchers with a greater understanding on the growth and development of planted giant cane and important practical knowledge to actively manage the species for restoration in Illinois. This and other work is contributing needed information to help achieve the Illinois Wildlife Action Plan goal of restoring canebrake habitat in the Cache and Wabash watersheds.

Prior and Future Dissemination of the Results of this Study

We have already disseminated the preliminary results of this study and acknowledgements of the IDNR's support for this study to other resource management professionals through presentations at the following regional and international professional meetings (* indicates presenter).

Zaczek*, J. J., J. E. Schoonover, S. G. Baer, K. W. J. Williard, J. W. Groninger. 2007. Cultural methods and restoration ecology of giant cane (*Arundinaria gigantea*). The Sixth North American Forest Ecology Workshop. June 18-20, 2007. Vancouver, British Columbia, Canada.

Brendecke*, W., J. J. Zaczek, and J. L. Hartleb. 2006. Giant Cane Restoration. The Illinois Society of American Foresters Fall Meeting, September 26-27, Ullin, IL.

Figure 9. Average (± 1 SE) culm diameter (mm) of giant cane in adjacent plots by treatment and over time. Difference among the treatment combinations within a year indicated by letters a-c; changes over time within a treatment combination indicated by letters x-z. Means accompanied by the same letter were not significantly different (α=0.05).

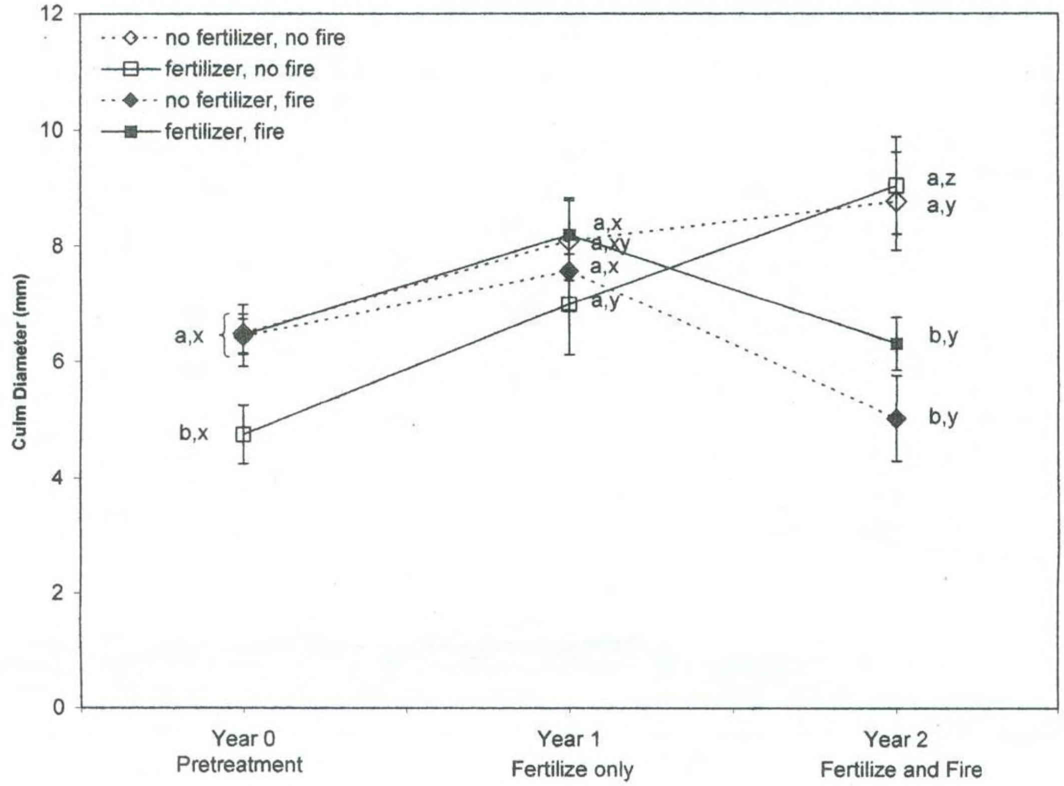


Figure 8. Average (± 1 SE) height (cm) of giant cane in adjacent plots by treatment and over time. Difference among the treatment combinations within a year indicated by letters a-c; changes over time within a treatment combination indicated by letters x-z. Means accompanied by the same letter were not significantly different (α=0.05).

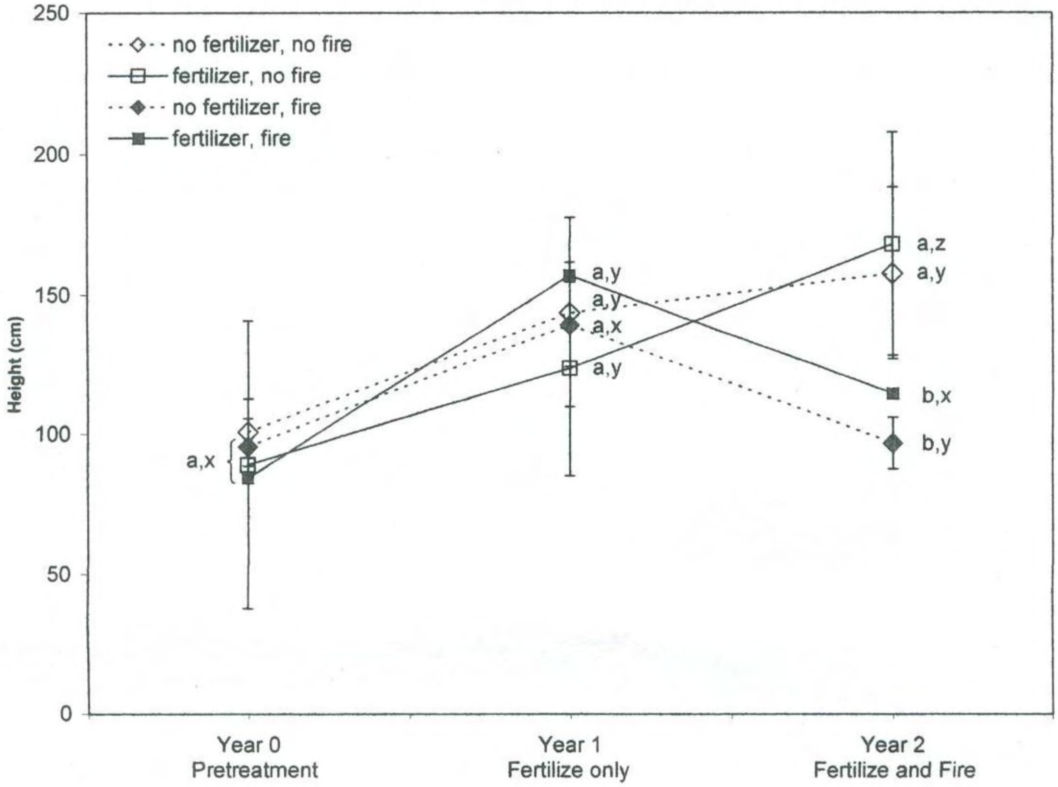
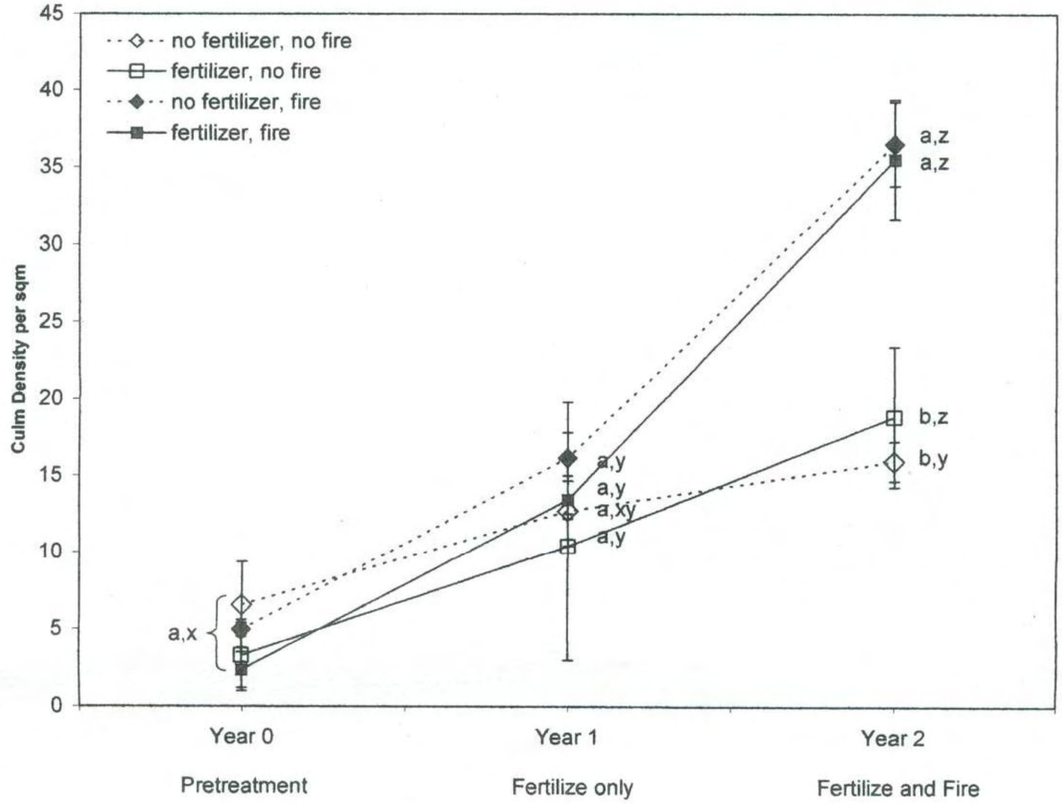


Figure 7. Average (± 1 SE) culm density of giant cane in adjacent plots by treatment and over time. Difference among the treatment combinations within a year indicated by letters a-c; changes over time within a treatment combination indicated by letters x-z. Means accompanied by the same letter were not significantly different (α=0.05).

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