Erigenia, Number 29, Spring 2025, pp 48–56

Relationships between Forest Cover and Canebrakes in Southern Illinois

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Abstract: Giant cane (*Arundinaria gigantea* [Walt.] Muhl.) is a woody perennial bamboo species native to the southeastern United States. Giant cane forms monodominant ecosystems, known as "canebrakes", that primarily occur in riparian areas and bottomland hardwood forests. Due to land conversion and alteration of disturbance regimes, canebrake ecosystems have drastically declined, and remnant stands now mainly persist as forest understory and edge vegetation. Although canebrake restoration efforts are increasing, information on the current conditions of canebrake remnants remains sparse. We assessed the relationships between forest characteristics and canebrake growth (i.e., culm density, culm height, and canebrake area) using generalized linear mixed effect models. Data were collected at 47 sites during June–August, 2023 in southern Illinois, USA. Canebrake area was negatively associated with overstory basal area, while midstory height and percentage herbaceous cover was positively associated with increased canebrake area. Cane culm density was negatively associated with leaf litter depth and percentage canopy cover, while culm density was positively associated with understory stem density. Culm height was negatively associated with midstory height, midstory density, understory density, and overstory density, while culm height was positively related to overstory basal area and percentage herbaceous cover. Understanding the relationship between canebrake conditions and forest characteristics can aid in determining which forest components should be managed to increase canebrake growth and vigor. Our findings corroborate previous studies indicating that overtopping forest tree competition is associated with limited giant cane growth, which emphasizes the importance of overstory management for canebrake conservation and restoration.

Introduction

Giant cane (*Arundinaria gigantea* [Walt.] Muhl.) is a woody perennial bamboo species native to the United States (Tucker 1988; Ward 2009; Triplett et al. 2010). Its distribution extends across 22 southeastern states from Maryland to eastern Oklahoma, southward to east Texas, and eastward to Florida (Marsh 1977). Giant cane occurs in almost any landcover type from dense forest to open lands mostly along hydric riverbanks and streams (Marsh 1977), but is also found on mesic, xeric, and sub-xeric upland sites (Platt 1999). It can form vigorous monodominant communities known as "canebreaks", characteried by dense aboveground culms and mats of spreading underground rhizomes in more open areas with few associated trees. Giant cane also occurs in less dense stands of reduced health and vigor in the understory of closed-canopy forests. Canebrakes vary in area and extent; they may occur in discrete patches or in continuous patches that extend over a large area (Gagnon and Platt 2008). However, the literature does not suggest a universally-accepted definition of the area, density, and ecosystem functionality of a cane patch that qualifies it as a canebrake. For this study, we referred to giant cane patches that were approximately 100 m^2 or larger as canebrakes.

Historically, canebrakes occupied a vast area throughout the southeastern United States; however, conversion of wetlands to agriculture and suppression of disturbances reduced suitability of habitats for giant cane growth (LMVJV 2007; Shoemaker 2018). Currently, less than 2% of canebrake ecosystems remains from their pre-settlement distribution and typically persist as forest understory and edge vegetation in Bottomland Hardwood Forests (BLH) or along fencelines (Marsh 1977; Noss et al. 1995; Brantley and Platt 2001).

Giant cane provides many ecological and cultural benefits. Historically, giant cane was an important part of the Native American culture and livelihood (Platt et al. 2009). Ecologically, canebrakes serve as a potential buffer

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species by improving soil and water quality, increasing soil infiltration rate, and enhancing soil organic matter content (Schoonover et al. 2005, 2010; Blattel et al. 2009; Singh et al. 2018). Moreover, canebrakes support a diverse wildlife community (Platt et al. 2001, 2013; Geise 2011). Due to the cultural importance and ecological services provided by giant cane, interest in the restoration of canebrake habitat has increased, particularly for mitigating erosion along streams and riverbanks, improving water quality, and providing habitat for terrestrial and aquatic organisms (NRCS 2021).

Although the effective area and quality of a canebrake to support various wildlife species is not well understood, historical canebrake conditions (i.e., dense and extensive) provided refuge for many wildlife species (Brantley and Platt 2001). In addition, dense understory vegetation including canebrakes are known to increase prey abundance and provide refuge for breeding, nesting, and foraging of many bird species (Wilson and Twedt 2003; Horn et al. 2005; Moorman et al. 2012). Understanding how giant cane growth and vigor is influenced by surrounding habitat is necessary to enhance canebrake characteristics to meet specific management goals.

In Illinois, much research has been done on propagation techniques for the reestablishment and expansion of existing canebrake stands (e.g., Zaczek et al. 2004; Brendecke and Zaczek 2008; Schoonover et al. 2011); however, information on the status of remnant canebrakes, which are fragmeneted and usually occur as less dense understory vegetation, remains sparse. In addition, giant cane is listed as a conservation target as a natural community in the Illinois Comprehensive Wildlife Conservation Plan (IDNR 2005) and The Joint Venture Partnership's Cache River Wetlands Site Conservation Plan (Bouska et al. 2012), emphasizing a need for appropriate and effective management actions to restore and to enhance remaining canebrake habitat.

Given the loss and fragmentation of BLH forests and canebrake habitats, obtaining information on the current distribution and characteristics of the remaining canebrakes, such as area and vigor, could aid in determining its ecological value and resiliency as sparse understory vegetation. Cane growth and survivorship within associated forest cover is positively affected by disturbances such as fire and windstorm forest blowdown which leads to an increase in light intensity from canopy gaps and reduction in woody competition (Gagnon and Platt 2008). Growth and vigor of giant cane respond positively to increased light intensity and nutrient availability such as nitrogen (Cirtain et al. 2009). Understanding canebrake status in relationship with associated forest cover characteristics could guide canebrake management practices to meet restoration and rehabilitation goals in promoting growth of remnant canebrakes by alteration of forest overstory conditions.

We aimed to understand the relationships between forest cover and canebrakes in southern Illinois. Specifically, we compared characteristics of canebrakes (i.e., density, height, and area) to forest characteristics that influence light intensity and nutrient availability (e.g., potential competitions and indicators of site quality) in southern Illinois. Forest characteristics associated with low light intensity such as high percentage canopy cover, leaf litter, and tree density were hypothesized to negatively influence canebrake density, height, and area (Gagnon et al. 2007; Gagnon and Platt 2008). In addition, we hypothesized that the presence of other herbaceous and woody shrub species could compete for nutrient and light by overtopping cane (Brantley and Platt 2001; Shoemaker 2018), and therefore, negatively affect cane growth.

Material and Methods

Study Area

Forty-seven study sites with established canebrakes of at least 100 m^2 in area were chosen in southwestern Illinois, USA, across Jackson, Union, Alexander, and Pulaski counties (Figure 1). In addition, canebrakes were required to be on public land due to permits and were not planted. Twenty-five, 7, and 15 study sites were located within the Cypress Creek National Wildlife Refuge, the Shawnee National Forest, and lands managed by the Illinois Department of Natural Resources, respectively. Forty-one sites were located within the non-glaciated area, while the other six study sites were located within the glaciated area and included a coal mine reclamation site, where mining operation concluded in 1992. Prescribed fire was included as a management action during the early stage of land restoration at the coal mine reclamation site. Although we did not observe any signs of burning at our study sites, prescribed burning was observed regionally within the large public land units. Dominant vegetation communities were oak-hickory forest associations. Haymond-Petrolia-Karnak soils, which form clay-sandy alluvium in floodplains drainages under deciduous forests (Fehrenbacher et al. 1984), were characteristic of study sites. Mean annual temperature of the study area is 15 °C, reaching 27 °C during the hottest month and 2 °C during the coldest month and the mean annual precipitation is 120 cm, with the growing season during April–October (Fehrenbacher et al. 1984; Robeson 2002).

Data Collection

Surveys were conducted during June–August 2023 at 47 sites. At the start of data collection in June, flooding from heavy rains in May had subsided and the emergence of new culms occurred across study sites. At each site, 10 m ×10 m sample plots were established in the center and at the edge of canebrake; sample plots were 30 m apart, measuring from the edge of the plots. If the canebrake was too small to fit multiple sample plots (ranging from 1–3 plots/site), only one sample plot was established at the center of the canebrake. Thirty-two sites contained only 1 sample plot, 10 sites contained 2 sample plots, and 5 sites contained 3 sample plots. We surveyed a total of 62 sample plots across all sites.

At each sample plot, we measured 11 site-specific variables that were hypothesized to affect cane growth (i.e., nutrient availability and light intensity [Brantley and Platt

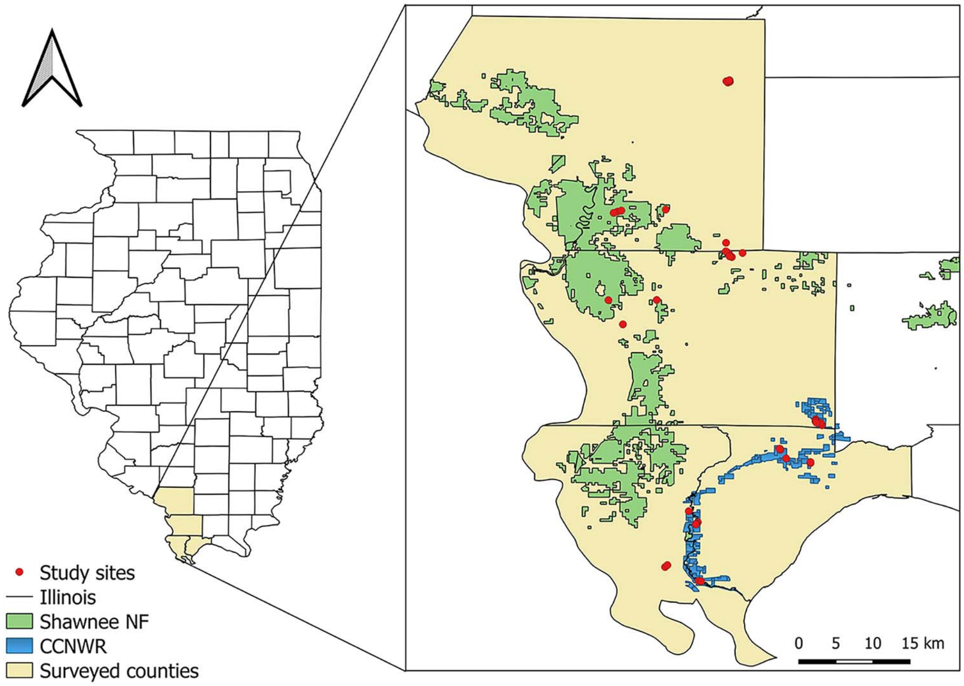

Figure 1. Map of 47 study sites (red dots) surveyed during June–August 2023 across Jackson, Union, Alexander, and Pulaski Counties in southern Illinois, USA. Study sites were located within Cypress Creek National Wildlife Refuge (CCNWR), Shawnee National Forest (Shawnee NF), and areas managed by the Illinois Department of Natural Resources (IDNR).

2001; Gagnon and Platt 2008; Cirtain et al. 2009; Shoemaker 2018]) including tree canopy cover (%), tree density (stems/ha, i.e., overstory, midstory, and understory), overstory tree basal area (m^2/ha), tree height in the overstory, midstory, and understory strata (m), percentage cover of shrub species (woody vegetation with < 1 m height), percentage cover of herbaceous plants, and leaf litter depth (mm). Trees were grouped into three categories: understory (< 3 m height), midstory (3-9 m height), and overstory (> 9 m height). Measurements were collected for trees that were within the boundary of sample plots; trees along the border of a sample plot were included if more than half of the base was within the sample plot. For each tree category, stem density (stems/ha) was calculated by multiplying the number of total stems counted within a sample plot (10 m × 10 m) by 100. Tree height to the nearest m was calculated by averaging the height of trees for each category within the plot using a laser range finder (Pariyar and Mandal 2019). Tree diameter at breast height (DBH) was measured 1.37 m above ground to the nearest cm using a diameter tape for trees in plots. Basal area (m^2/ha) was calculated for each tree using the formula for the area of a circle, $\pi*(DBH/2)^2$ and summed by groups of overstory trees. Percentage tree canopy cover (overstory and midstory trees) was measured to the nearest 1.0% using a convex spherical densiometer at four cardinal directions around the center of the sample plot, and the mean was taken among all four directions (Lemmon 1956).

Within each sample plot, we established 5 subplots and followed the Daubenmire method (Daubenmire 1959) within a 1 m^2-quadrat to estimate percentage of shrub and herbaceous cover at the center of the sample plot and at 5-m distances from the center in the four cardinal directions. Six cover classes were used: 0–5%, 5–25%, 25–50%, 50–75%, 75–95%, and 95–100% (Daubenmire 1959). Leaf litter depth was measured using a ruler to the nearest mm at the center of the sample plot and at 5-m distances in the four cardinal directions from the center and averaged for each plot. Giant cane culm density (stems/m^2) was measured using a 1 m^2-quadrat at the center of the sampling plot and at 5-m distances from the center in four cardinal directions. In addition, culm height (cm) was measured using a meter stick to the nearest cm and averaged for all older (> 1 year) live culms among 5 quadrats. Density (culms/m^2) of first-year culms, newly emerged culms with the presence of culm sheath, older culms, and dead culms were determined within each quadrat. The area of each canebrake was also measured (to the nearest m^2) by walking the perimeter of the site with a GPS-unit to delineate a polygon.

Statistical Analyses

To assess the relationships between forest variables and cane growth, we used generalized linear mixed-effect models with gamma distribution and log-link function in R packages 'lme4' (Bates et al. 2009). We tested 3 models that we determined to be measures of cane growth: 1)

Table 1: Summary forest and canebrake measurements taken during June–August 2023 across 62 sample plots in southern Illinois, USA.

Forest variables	min	max	mean (standard deviation)
Percentage tree canopy cover (%)	66.8	99.8	95.1 (8.2)
Overstory density (stems/ha)	0	800	114.5 (199.9)
Overstory basal area (m^2/ha)	0	147.2	40.3 (37.9)
Overstory height (m)	9.1	38.0	15.3 (5.5)
Midstory density (stems/ha)	0	1,000	350 (232.4)
Midstory basal area (m^2/ha)	0	53.0	4.8 (8.2)
Midstory height (m)	3.7	9.0	6.3 (1.6)
Understory density (stems/ha)	0	1,000	396 (271.3)
Understory height (m)	2.0	3.0	2.7 (0.5)
Percentage cover of shrub (%)	0	17.0	0.6 (2.5)
Percentage cover of herbaceous (%)	0	49.5	13.4 (11.7)
Leaf litter depth (mm)	0	39.6	8.9 (9.3)
Canebrake variables			
Live culm density (culms/m^2)	1.2	24	6.0 (4.1)
First-year culm density (culms/m^2)	0	5.6	0.7 (1.2)
Old culm density (culms/m^2)	0.8	20.8	5.3 (3.5)
Dead culm density (culms/m^2)	0	12.6	2.05 (2.0)
Culm height (cm)	46.5	372.5	116.9 (57.1)
Canebrake area (m^2)	104.3	24,726.3	1,602.0 (4,100.2)

culm density (live culms, both first-year and old culms), 2) culm height (old live culms only as new culms may have not fully expanded in height and diameter for plots measured in early summer vs those in late summer), and 3) canebrake area. We treated site as a random effect to account for variations between sites which could affect giant cane growth pattern. We used a generalized linear model with the gamma distribution and log-link function to fit a model to assess the relationship between forest variables and the area of canebrake at each site. The forest variable measurements were averaged among the sample plots for each site in the canebrake area model.

Prior to running the analyses, highly correlated variables ($|r| \geq 0.7$) were eliminated from further consideration based on a Pearson's correlation test. We found a strong correlation between understory tree height and overstory stem density ($r = 0.7$); therefore, we removed understory tree height from the predictor variables due to its minimal biological effect on light availability for giant cane. Additionally, due to a low average percentage shrub cover (< 0.6%) across our sample plots where shrubs were present, we removed percentage shrub cover as a predictor variable. All variables were standardized to a mean of 0 and standard deviation of 1 and outliers (i.e., data points that fell below or above the upper and lower bounds based on the length of 1.5 times the interquartile range) were removed prior to analysis (Tukey 1977). For the canebrake area analysis, the sample size was 37 sites after outliers were removed. For the culm density and culm height analyses, the sample size was 60 sample plots after outliers were removed. We used backward elimination approach for model selection as described in Zuur et al. (2009). A variable with the highest p-value was eliminated, then the process was repeated until all remaining variables were significant ($p < 0.05$). Significant variables were then included in the final model. In addition, for each final model, we calculated r-squared values to assess model explanatory performance. Relative importance of predictors were calculated for each model using the package 'glmm.hp' (Lai et al. 2022). All statistical analyses were performed in R version 4.2.3 (R Core Team 2024).

RESULTS

Canebrakes were found in small discrete patches and in larger areas on continuous tracts of land (Table 1). They varied in size and morphology across our study sites, ranging from an area of 104 m^2 to 24,726 m^2 ($\bar{x}$ = 1,602.1 m^2), a live culm density range of 1.2–24.0 culm/m^2 ($\bar{x}$ = 6.0 culm/m^2) and culm height that ranged from 46.5 cm to 372.5 cm ($\bar{x}$ = 116.9 cm; Table 1). The differences in numbers of live culms and dead culms varied across sites; three sites had greater numbers of dead versus live culms. Canebrakes also differed in regeneration rate, by which the percentages of new culms in comparison to the total culms (dead and live culms) ranged from 0.0 to 42.9% ($\bar{x}$ = 8.2%). Canebrakes were found in locations that were forested or forest-adjacent with a wide range of overstory tree densities, from no trees to 800 stems/ha (Table 1).

Table 2: Significant forest variables based on the final models for: 1) canebrake area, 2) culm density, and 3) culm height using backward-elimination approach for model selection. Marginal (R^2m; variances explained only by the fixed effects) and conditional r-squared (R^2c; variances explained by the fixed effects and random effects) values are reported for each model. Relative importance of each variable is represented by the marginal R^2.

Variables	Coefficient	Standard error	P-value	R^2
Canebrake area ($R^2m = 0.37$)				
Intercept	5.94	0.08		
Percentage herbaceous cover	0.16	0.08	0.060	0.07
Understory density	0.22	0.08	<0.001	0.10
Overstory basal area	−0.27	0.07	<0.001	0.20
Culm density ($R^2m = 0.33$, $R^2c = 0.86$)				
Intercept	1.43	0.14		
Percentage canopy cover	−0.33	0.09	<0.001	0.10
Understory density	0.25	0.06	<0.001	0.10
Leaf litter depth	−0.37	0.10	<0.001	0.13
Culm height ($R^2m = 0.26$, $R^2c = 0.88$)				
Intercept	4.61	0.08		
Percentage herbaceous cover	0.08	0.03	<0.001	0.03
Midstory height	−0.06	0.03	<0.001	0.02
Overstory basal area	0.09	0.02	<0.001	0.03
Midstory density	−0.06	0.02	<0.001	0.03
Understory density	−0.07	0.03	<0.001	0.04
Overstory density	−0.15	0.05	0.020	0.11

Other forest-based measurements relating to understory, midstory, and overstory characteristics also varied across sample plots (Table1).

For the canebrake area analysis, three variables were among the top model including overstory basal area, percentage herbaceous cover, and understory density, of which two were statistically significant predictors (p-value < 0.05; Table 2). Of these variables, overstory basal area was negatively associated with canebrake area and accounted for the most variation ($R^2 = 20\%$; Figure 2). Understory density and percentage herbaceous cover were positively associated with increased canebrake area, together accounting for ~17% of the variation (Figure 2a).

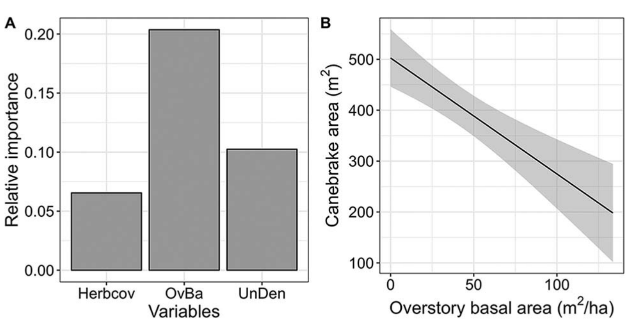

Figure 2. A) Relative importance of individual predictors within the top models for predicting canebrake area (m^2) including percentage herbaceous cover (Herbcov), understory density (UnDen), and overstory basal area (OvBa). B) Predicted plot with standard errors showing the effect of overstory basal area, which was a predictor with the highest relative importance value (R^2) on canebrake area (m^2), using the 'add_ci' function in R.

For culm density analysis, three explanatory variables were statistically significant (p-value < 0.05; Table 2), including percentage canopy cover, understory density, and leaf litter depth. Cane culm density was negatively associated with leaf litter depth and percentage canopy cover accounting for a total ~23% of the culm density variation ($R^2 = 13\%$ and 10%, respectively; Figure 3). Understory density was positively associated with culm density accounting for ~10% of the variation (Figure 3a).

For culm height analysis, six variables were statistically significant (p-value < 0.05; Table 2). Height predictors including percentage herbaceous cover, midstory height, overstory basal area, midstory density, understory density, and overstory density together accounted for 26% of the variation in culm height (Figure 4). Culm height was negatively associated with most variables, accounting for 20% of the variation (Table 2). Only overstory basal area and percentage herbaceous cover were positively related to culm height.

Discussion

Historically, canebrakes occupied hundreds of thousands of hectares throughout the southeastern United States

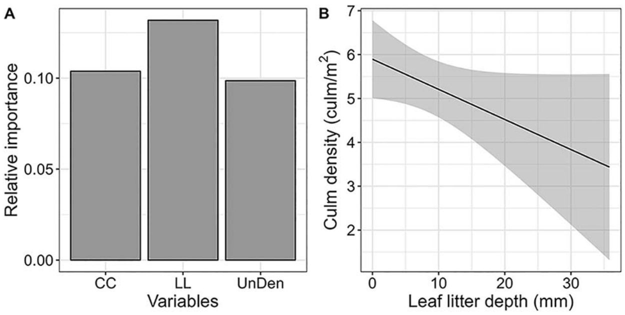

Figure 3. A) Relative importance of individual predictors within the top models for predicting culm density (culm/m^2) including percentage canopy cover (CC), leaf litter depth (LL), and understory density (UnDen). B) Predicted plot with standard errors showing the effect of leaf litter depth (mm), which was a predictor with the highest relative importance value (R^2) on culm density (culm/m^2), using the 'add_ci' function in R.

including southern Illinois (Brantley and Platt 2001). Roosevelt (1908) described canebrakes in Louisiana as going on for "miles". However, the southern Illinois cane patches observed in this study were relatively small with a mean of 0.16 ha. Canebrake area reduction is thought to be a result of overgrazing from livestock, agricultural land conversion, and lack of the historical disturbance regime which included fire and flooding (Marsh 1977; Platt and Brantley 1997; Brantley and Platt 2001). Though it is not well understood how large a cane patch must be to be ecologically functional, most giant cane in southern Illinois has been relegated to scattered patches adjacent to agricultural fields along stream edges, fence lines, roadsides, ditches, and under and adjacent to forest stands. Giant cane stands growing in riparian zones can function to reduce excess nutrients such as nitrate in groundwater by 90% in the first 3.3 m from an agricultural field edge (Schoonover and Williard 2003; Schoonover et al. 2005). Geise (2011) found a diverse community of invertebrates inhabiting canebrake of less than 0.1 ha. However, more research is needed to evaluate how large a patch or stand of cane needs to qualify as an ecologically functional canebrake.

We documented several forest characteristics explaining 37%, 34% and 26% of the variation in canebrake area, cane culm density, and culm height, respectively. However, no single forest characteristic affected all cane growth parameters consistently. The relationships between giant cane and individual forest factors, though significantly related, did not alone account for more than 20% of the variation which was the case for overstory basal area and canebrake area. Canebrake area decreased as forest basal area increased, indicating that more intact and less disturbed forests limits canebrake area. Forests with high levels of basal area are likely to be old and more structurally developed, have high levels of canopy cover, and have not recently received substantial canopy-level disturbance to open large gaps in the overstory. However, it is important to note that the basal area values reported in our study was extrapolated from a small subplot size; therefore, they were sensitive to the presence of any large trees (>20 DBH) and might not represent the characteristics of the forest stands. Although interpretation of the forest structure should be done with caution, the relationship between canebrake characteristics and relative basal area among sites still represented the relationship between large overtopping trees and small canebrake habitat. Disturbances such as periodic fires and windstorms that reduce forest canopy cover and thus increase understory light levels and reduce below-ground competition are important for canebrake growth and vigor given giant cane is a disturbance-dependent species (Marsh 1977; Gagnon and Platt 2008; Cirtain et al. 2009).

Although some sample plots did not contain any overstory trees, thus zero basal area, all plots had canopy cover recorded which resulted from nearby overstory and midstory trees as indicated by a minimum sample plot

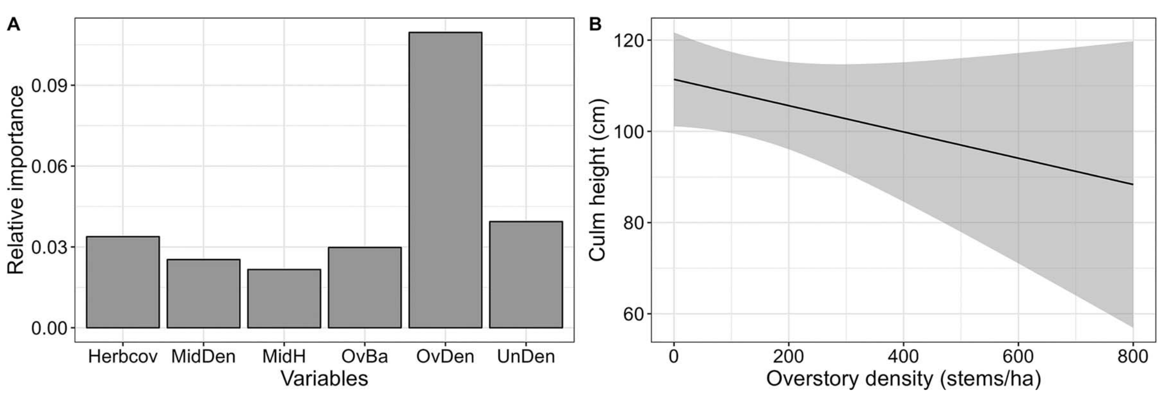

Figure 4. A) Relative importance of individual predictors within the top models for predicting culm height (cm) including percentage herbaceous cover (Herbcov), midstory density (MidDen), midstory height (MidH), overstory basal area (OvBa), overstory density (OvDen), and understory density (Unden). B) Predicted plot with standard errors showing the effect of overstory density (stems/ha), which was a predictor with the highest relative importance value (R^2) on culm height (cm), using the 'add_ci' function in R.

canopy cover of 66.8%. Culm density was negatively associated with canopy cover. Closed canopy limits light availability, which could inhibit cane growth (Cirtain et al. 2003; Gagnon et al. 2007). Additionally, culm density was negatively related to leaf litter depth. The result was not unexpected as leaf litter depth would have inputs from overstory, midstory, and understory trees, which could also reflect the amount of light availability. Cane culm density was low with a mean of 6.04 culms/m^2 compared to 16.5 culms/m^2 for 11 other remnant cane patches of unknown ages growing in riparian zones with scattered tree cover adjacent to agricultural fields in southern Illinois (Anderson 2014). Additionally, in the region within a single location, a mean culm density of 21.8 +/− 3.0 culms/m^2 was recorded across 60 plots distributed within an 11-year-old 0.2 ha giant cane nursery with little to no canopy cover at Southern Illinois University (Ganden, unpublished data). Moreover, we found that only 10% of the variation in culm density was associated with percentage canopy cover, so other unmeasured factors influence culm density. Cane height was negatively associated by increased overstory, understory, and midstory density and midstory height accounting for 20% of the variation. In our study, mean cane height was 116.9 cm which is less than 241.4 cm at the open-grown cane nursery at Southern Illinois University (Ganden, unpublished data) and 242.7 cm in Anderson's (2014) study.

There were mixed but weak correlations between cane growth and understory factors. Canebrake area was positively associated with increased understory density and percentage herbaceous cover. Also, cane density was positively related to understory density suggesting that conditions favorable for cane density also benefit other woody understory plants. This was expected because areas with increased light level promote cane culm production (Gagnon et al. 2007) as well as understory vegetation growth, which could explain the positive trends between understory density, herbaceous cover, and culm density observed in our study.

Regeneration of new culms is important in determining persistence and vigor of canebrakes. Although we did not directly study the regeneration rates of cane culms, we observed 3 sites with more dead culms than live culms. In addition, we also observed 8 sites with no new culms at the time of our surveys. Large numbers of dead culms and relatively low number of new culms observed (8.18%) could indicate nutrient limitation at our sites (Zaczek et al. 2010). Increasing nutrient and light availability and reducing competition through prescribed burning can promote new culm growth and emergence (Cirtain et al. 2003; Dattilo and Rhoades 2005; Zaczek et al. 2010). In addition, large numbers of dead culms could be a result of flowering events. Although sexual reproductive ecology of giant cane is not well-studied, it is inconsistent and unpredictable characterized by long intervals of vegetative growth with monocarpic flowering events that may occur every 20 to 25 years or more (Hughes 1951; Marsh 1977; Gagnon and Platt 2008). Habitat fragmentation also creates an additional barrier to cane regeneration; culms within a stand often belonged to a single clone with low seed viability and low rate of germination, perhaps due to self-incompatibility (Mathews et al. 2009).

In this study, the area of cane patches and the density and height of giant cane culms were mainly limited by overtopping overstory forest tree competition. Because we only measured these stands once, we cannot definitively state that forest competition limited the area or spread of cane patches. However, it is likely that expansion of cane patches was limited by associated forest cover since cane vigor (height and density) was considerably lower compared to other measured open-grown cane patches in the region.

Summary and Management Recommendations

Based on our findings, management of overstory trees can improve growth of existing canebrakes. To rehabilitate remnant cane stands under dense forest cover, land managers should consider reducing forest overstory basal area and percentage canopy cover through thinning alone, prescribed fire alone or thinning and prescribed fire in combination. Timing, intensity, and frequency of fire should be considered for maintaining canebrakes (Hughes 1966; Gagnon and Platt 2008; Zaczek et al. 2010) as it is a disturbance-dependent species. For example, burning at an interval of 10 years was optimal for cane (Hughes 1966). Although prescribed fire applied to a developing 6-year-old cane restoration planting decreased culm height and diameter, it also increased culm density within the planting and spread into adjacent areas one year after treatment (Zaczek et al. 2010), thus benefitting the persistence and expansion of giant cane stands. Reduction of overstory vegetation would increase understory light levels and soil resources, improving the vigor of cane and other understory plants. Moreover, to prevent a mass die-off following flowering, propagating cane using rhizomes from multiple stands and clones can promote genetic diversity and seed viability (Mathews et al. 2009).

Acknowledgments

Many thanks and appreciation for the support provided by the Illinois Native Plant Society and the McIntire-Stennis Cooperative Forestry Research Program of the National Institute of Food and Agriculture of the USDA project accession number 7004275. We would like to thank Illinois Department of Natural Resources (permit # SS23-08), Cypress Creek National Wildlife Refuge (permit # 2023-001R), and Shawnee National Forest (permit # 2600) for the access to study sites. In addition, we would like to thank Jacob Trowbridge, Laura Schammel, Madison Woods, and Hannah Bendler for assisting in data collection.

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