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PRESCRIBED FIRE EFFECTS IN THE OZARKS OF MISSOURI: THE CHILTON CREEK PROJECT 1996-2001

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1. ABSTRACT

The Chilton Creek basin is a 1,012 hectare (2,500 acre) forested area of the dissected breaks adjacent to the Current River, southeast Missouri Ozarks. Owned and managed by The Nature Conservancy (TNC), the basin has been under a frequent prescribed fire regime since 1998. In 1996, the Missouri Department of Conservation (MDC) established 250 0.2-hectare (0.5 acre) permanent monitoring plots in the basin using stratified random placement of plots by slope, aspect, topographic position, and geologic substrate. Pre-treatment data was collected in 1996 and 1997 from 4000 1 m² herbaceous quadrats and on 50,607 woody stems in all size classes. Herbaceous vegetation was re-sampled in 1998 and 2001. Woody stems were re-sampled in 2001.

Pre-treatment data shows a well developed understory and mid-story as a result of a fifty year fire free interval of the mid to late 1900's. Uneven-age timber harvests during this interval favored development of Black Oak (*Quercus velutina*) and Scarlet Oak (*Q. coccinea*) over previously more abundant Shortleaf Pine (*Pinus echinata*), White Oak (*Q. alba*) and Post Oak (*Q. stellata*). The 1996-97 ground layer was dominated by hardwood leaf litter with average vegetative cover of only fifteen percent. Of that vegetation, 46% were seedlings of trees and shrubs, 19% legumes, 16% broadleaf herbs, 9% grasses and sedges, 8% woody vines, and 2% ferns. Historic vegetation descriptions of these woodlands prior to 20th Century fire suppression described a ground layer dominated by grasses, sedges, and broadleaf herbs. Despite the presence of over 500 non-woody species in the basin, only five non-woody species were in the top 20 Relative Importance Values from quadrat sampling. Two legumes (*Desmodium nudiflorum* and *Amphicarpa bracteata*) and one shrub (*Sassafras albidum*) dominated nearly 20% of the ground layer vegetation. Diversity was 11.5 species per quadrat with 465 species of vascular plants occurring in the entire 4000 m² sampled. Non-native taxa represented less than one percent of the flora sampled.

Data from 2001 sampling shows drastic reductions in understory and midstory woody stems, an increase in woody seedlings in the ground layer including copious basal sprouts, and an increase in herbaceous ground layer vegetation. Woody stems less than 4 cm dbh were reduced from 13,002 in 1997 to 6,891 in 2001 (47%). Species considered fire tolerant and fire intolerant were both impacted. Shrubs and early successional woody species such as Redbud (*Cercis canadensis*), Persimmon (*Diospyros virginiana*), and Sassafras (*Sassafras albidum*) increased in number. Woody stems in the 4 – 11 cm dbh size class were reduced at a lesser rate from 18,032 to 12,967 (28%). White oaks in this category such as *Q. alba* and *Q. stellata* had mortality rates of 22% and 29 % respectively, while red oaks such as *Q. coccininea* and *Q. marilandica* were reduced 52% and 60% respectively. Mortality in overstory trees (dbh >11 cm) increased from 4% of the 1997 sample to 11% of the 2001 sample. The understory and midstory that developed in the absence of fire has been reduced. There appears to be adequate recruitment of small woody stems to maintain overstory trees. Tree species composition is still not representative of what would be expected on a fire managed landscape due to increased resistance of larger trees of all species to fire mortality. This composition is expected to change over time as repeated fires are applied.

The ground layer in 2001 was still dominated by hardwood leaf litter but average vegetative cover increased from 15% to 24%. Trees and shrubs in the ground layer decreased considerably from 46% to 33% and woody vines decreased slightly from 8% to 6%. Legumes increased from 19% to 30% and grasses and sedges increase modestly from 9% to 13%. The number of herbaceous species in the top 20 RIV increased from five to nine species with Bosc's Panic Grass (*Panicum boscii*) and Woodland Sunflower (*Helianthus hirsutus*) increasing dramatically in frequency, and the two most common legumes (*Amphicarpa bracteata* and *Desmodium nudiflorum*) increasing fivefold in cover. Diversity increased slightly: from 11.5 to 12.2 species per quadrat, and from 465 to 482 species occurring in the 4000 m² sampled. Increase in ground layer vegetation has resulted from a flush of vegetative growth by already established perennial forbs, mostly legumes. An increase in the abundance of opportunistic native annuals such as Fireweed (*Erechtites hieracifolia*) occurred after initial fires but relative abundance of the annuals has decreased in subsequent seasons. Fires continue to stimulate flowering and seed production in perennial grasses, sedges, and forbs, and to create bare ground

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for seedling establishment. But herb seedling establishment in the rocky and excessively drained soils of this basin is slow. It is expected that ground layer change from a low diversity leaf litter and woody species dominated vegetation to a moderate diversity broadleaf herb and graminoid dominated vegetation may take decades of fire rather than a few years.

2. Introduction

Natural cover fires have been part of the Ozark landscape for centuries (Guyette, 1982). Accounts from early explorers and naturalists indicated a large percentage of the fires were anthropogenic, caused by humans (Schoolcraft, 1821). Early recorded history, plus the evolutionary adaptations of the native plants of the Ozark region to fire further indicate that periodic fires have been a long term disturbance force on the landscape (Ladd, 1991).

Success of a fire suppression program, initiated in the 1930's by the U.S. Forest Service and Missouri Department of Conservation, created a landscape where periodic fires impacted the landscape far less frequently than in the past (Westin, 1992). Following this reduction or cessation of wildfires, the environmental pressures which created the native landscape have been altered so that plant communities no longer have the diversity or environmental stability of the past when fire was an integral part of the natural landscape (Beilman and Brenner, 1951).

Problems of natural community alterations, including the overall health of Missouri's forests, may be solved or lessened by reintroducing fire into the forest system. Part of the desirability of reintroducing fire into a system of communities is the variety of effects it exhibits over a landscape depending on the weather, slope, aspect, and fuel conditions of each part of the landscape (NWCG, 1981). Fragmentation of the landscape within the Ozarks due to roads, small ownerships and development projects generally preclude the use of fire on major expanses of land.

TNC's Chilton Creek Management Area is a 5,657 acre site located in a remote portion of the Missouri Ozarks along the Current River in Shannon and Carter counties, Missouri, approximately five miles north of the town of Van Buren (Figure 1). The site lies within the Current River Hills subsection of the Ozark Highlands (Keys et al. 1995), an area characterized by rugged, steeply dissected valleys and hollows, and narrow ridges. Soils are prevailingly poor and excessively drained, developed over dolomite and sandstone karst bedrock.

Potential natural vegetation in the area is a complex of dry to mesic Shortleaf Pine/Oak forest-woodland-savannah, within which occurs a diversity of specialized habitats. These specialized habitats include: fens, dolomite glades, xeric woodlands, cliffs, springs and associated spring-fed creeks, caves, sinkhole ponds, and riparian hardwood forest habitats along the Current River.

The Chilton Creek site has been degraded in a variety of ways since settlement, including soil erosion from past livestock grazing, altered fire regimes, and altered tree densities and composition. Open range grazing of hogs and cattle was commonplace in the region from the mid-1800's until the 1950's, and is likely to have resulted in significant topsoil erosion on the steep slopes of the site. Soil losses also resulted from early timber removal practices such as cable skidding of logs down slopes (Schwartz, 1996). Modern fire frequencies are extremely reduced from previous centuries, occur mostly in the spring as opposed to aboriginal fall burning (Ladd, 1991), and burn typically under hotter "wildfire" conditions aggravated by greater fuel loads of the modern forest. Direct manipulation by historic logging has reduced the prevalence of shortleaf pine as a dominate canopy species in the region (Batek, 1994), as well as reduced the relative abundance of white oaks. Canopy tree size distributions at the site appear to have changed from high basal area-low stem densities to low basal area-high stem densities. These alterations have changed the biological composition, diversity, and structure of the site, and appear to be leading to a steady decline in remnant natural integrity, lower species richness and aggregate species conservatism.

TNC's management goal on the Chilton Creek Management Area is to sustainably conserve the native biota in diverse, interactive arrays comprising a mosaic of high quality native habitats. To this end, the reintroduction of a high frequency, low intensity fire regime at the site has been accompanied by intensive monitoring of biotic and abiotic responses and fire variables such as frequency, timing, intensity, and fuel conditions. This monitoring provides a unique opportunity to document the relationships between fire management and biological diversity, and yield information useful to woodland management and biological diversity conservation elsewhere in the Interior Highlands.

This paper reports the response of the herbaceous and woody vegetation to the reintroduction of a fire regime during the years of 1997 through 2001.

3. Methods

The study site on the Chilton Creek Management Area consists of the Chilton Creek Basin, 1,012 hectares (2,500 acres) located in the center of the property (Figure 1). The study site is subdivided into five fire management units. One unit, Kelly North, is burned annually. The other four units are burned at various random 1-4 year fire return intervals. All units were burned during the first year of treatment – 1998. The burning selection, by year, for the units is shown in Table 1.

In 1996, the Missouri Department of Conservation established 250 0.2 hectare (0.5 acre) plots within the study area to sample fire effects on the herbaceous and woody vegetation. The nested sampling plots are the same design as an adjacent study evaluating timber harvesting scenarios (Brookshire et al, 1997). This sample design was selected to facilitate comparisons between the two studies.

Sample plot placement was stratified by Ecological Land Type (ELT) based on the slope, aspect, topographic position and geologic substrate (Miller, 1981). Plot locations were randomized within ELT.

Plots were sampled in 1996 and 1997 to collect pretreatment data prior to dormant season burns early in 1998. Herbaceous vegetation was resampled in the summers of 1998 and 2001. Woody stems were resampled in the winter of 2001/2002.

Herbaceous information was collected on 16 $1m^2$ quadrats per plot. Herbaceous plants were identified to species and coverage within the quadrat assigned by percent foliar cover. Nomenclature followed the original Flora of Missouri (Steyermark, 1963).

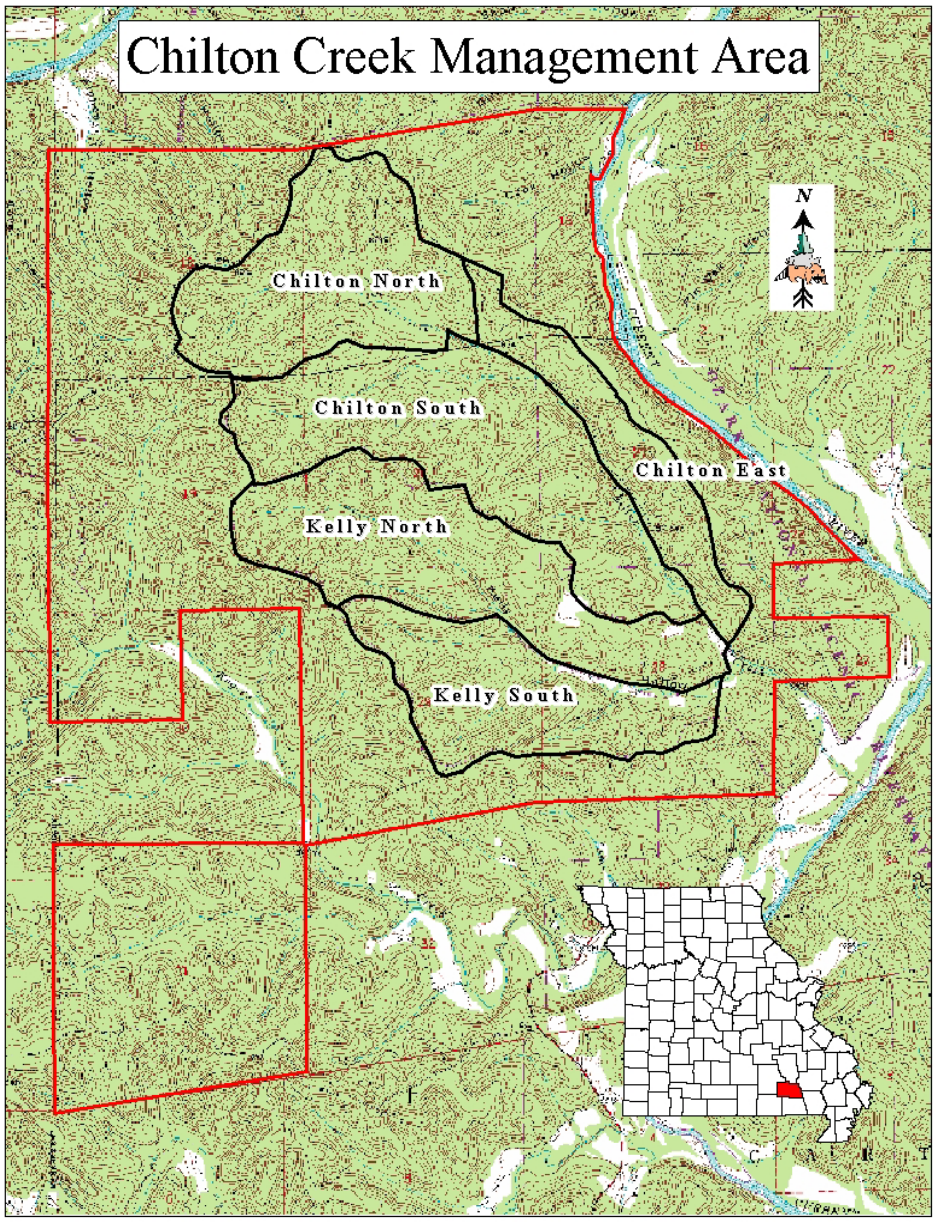
Woody stems 11 cm (4.5 in) and larger were recorded on the entire 0.2 ha (0.5 ac) plot to species and diameter-at-breast-height (dbh). Woody stems 4 to 11 cm (1.5 to 4.4 in) dbh were recorded on 4 subplots per plot totaling 0.08 ha (0.2 ac). These stems were also recorded by species and dbh. Small woody stems over 1.5 meter tall but less than 4 cm (1.5 in) dbh were recorded by species and size class on 4 hundredth-acre (.004 ha) plots within the plot. Stems 1 cm (0.5 in) or less were a Class 1 and stems >1 but less than 4 cm (0.5-1.4 in) were recorded as Class 2. Seedling woody vegetation was recorded from the herbaceous quadrats.

Burns were conducted in the dormant season, in spring 1998, 2000, and 2001 just prior to or as the vegetation was breaking dormancy and in the fall 1998 following hardwood leaf drop and killing frosts. The units were ignited on the boundaries with interior ignitions through major draws and other topographic features to speed the completion of burnout. No attempt was made to ignite all areas within burn units. Topographic variation and natural fuel breaks within units resulted in typical burn coverage of 60-90 percent. Burn coverage was recorded after each burn to document patch dynamics within units. Fuels were predominantly hardwood litter, Fuel Model 9, with small areas of warm season grass fuels on glades and exposed slopes, Fuel Model 2 (Anderson, 1982). Burns were conducted in typical Midwestern prescribed fire conditions with fine fuel moistures typically 6-10 percent. Topographic slopes of 15 to 30 percent are typical over the area. Fires were low to moderate intensity surface fires with flame lengths seldom exceeding 5 feet. Most flames were 1 – 3 feet in length. Containment issues typically involve short distance spotting along downwind perimeter and an abundance of burning and falling snags and other heavy fuels.

TABLE 1: Units burned on the Chilton Creek Management Area, 1998 – 2001.

Fire Unit	Spring 1998	Fall 1998	Spring 2000	Spring 2001
Kelly South	**X**		**X**	**X**
Kelly North	**X**	**X**	**X**	**X**
Chilton South	**X**	**X**	**X**	
Chilton North	**X**			
Chilton East	**X**			

Figure 1: Chilton Creek Study Area



4. Results and Discussion

Pretreatment Condition

The study site had a closed canopy overstory with an abundance of black oak (*Quercus velutina*), white oak (*Q. alba*), and scarlet oak (*Q. coccinea*) and a well developed understory and mid-story dominated by flowering dogwood (*Cornus florida*), white oak, and hickory (*Carya spp*). The ground layer was dominated by deep accumulation of hardwood litter with a low diversity and coverage of herbaceous vegetation.

These conditions are not indicative of those reported by early explorers and naturalists of the 18th and early 19th centuries, prior to European settlement of southern Missouri. At that time, the southeast Missouri Ozarks landscape was dominated by large diameter shortleaf pine (*Pinus echinata*) and white oak, frequently with widely scattered trees with grasses and forbs abundant in the ground layer and limited woody understory and midstory trees (Houck, 1908; Sauer, 1920; Schoolcraft, 1821). Probable reasons for these changes include 19th and 20th century logging pressures and open range grazing of cattle and hogs, and the late 20th Century cessation of periodic fires.

Logging during the late 1800's and early 1900's selected for the abundant shortleaf pine and white oak. Subsistence farming by families unemployed after the logging boom promoted open range grazing within the Ozarks by cattle and hogs that persisted until the 1950's. Fire suppression efforts, starting in the 1930's, led to a 50+ year relatively fire free interval during the mid to late 1900's.

Overstory tree (dbh > 11cm) composition during the pretreatment sampling favored the red oak family (black, scarlet) over either the white oak family (white, post) or shortleaf pine (Table 2). Black and scarlet oak averaged 5.6 m^2 /ha of basal area across the study site while white and post oak averaged 3.5 m^2 and shortleaf pine only 0.9 m^2 of basal area per hectare. Black oak were larger with an average dbh of 24.3 cm, while white oak averaged 19.0 cm dbh. Shortleaf pine averaged 22.3 cm dbh, but had only 23.3 stems per hectare as opposed to black oak at 73.4 stems and white oak at 92.8 stems per hectare. There were 15 standing dead trees greater than 11 cm per hectare on the sampled plots. Black oak was the most common followed by scarlet oak and white oak (Table 3). The majority of standing dead trees for all species were less than 21 cm dbh, but 13 percent were greater than 31 cm dbh.

The midstory (dbh 4-11 cm) that had developed on the site prior to treatment averaged 893 stems per hectare. Flowering dogwood was the most numerous with black gum (*Nyssa silvatica*), another shade tolerant but fire intolerant species in the top 5 species recorded (Table 4). The three other species making the top 5 in density were white oak, pignut hickory (*Carya glabra*) and mockernut hickory (*C. tomentosa*). The average diameter for all midstory species was 6.2 cm (2.5 in). Diversity was much higher in the midstory (74 species) than the overstory (43 species).

Understory woody vegetation (< 4 cm dbh) was initially recorded at 3,211 stems per hectare. There were 96 different woody species recorded in this size class. Flowering dogwood (Table 5) was the most common (663 stems/ha) with the next closest species white oak at 232 stems/ha. Sassafras (*Sassassafras albidum*), red maple (*Acer rubrum*), and black gum were the next most common woods plants. Each of these are indicative of closed woodlands with a management history lacking fire.

The ground layer was dominated by leaf litter (Table 7) at 90% with a mean foliar vegetation cover of only 15%. Bare ground, exposed rock, and down dead wood occupied a scant 0.66%, 4.24% and 3.2% respectively. The vegetation in this layer is the most diverse containing over 500 of the over 700 native species known from the site. An impressive 465 species occurred in the 4000 m² sampled. Mean diversity was 11.5 taxa per quadrat with creek bottom and glade plots averaging as much as 33 taxa per quadrat and some acid upland pine-oak woods plots averaging a few as 3 taxa per quadrat.

Ground layer vegetation was dominated by woody trees and shrubs (Table 8) with 46% of the total cover and legumes with 30%. Of the top twenty taxa in Relative Importance (Table 9), fifteen are woody species and five are herbaceous. Two legumes, bare-stem tick trefoil (*Desmodium nudiflorum*) and hog peanut (*Amphicarpa bracteata*) dominated the vegetation along with the woody shrub sassafras. Less than one percent of the total flora sampled was non-native species, with tall fescue (*Festuca elatior*) one of the most common in disturbed creek bottom areas.

Post Treatment Condition

Following one to four fires, depending on burn unit (Table 1), the herbaceous and woody vegetation was resampled. Dead trees greater than 11 cm dbh increased from 744 (4% of total sample) to 2,257 (11% of total sample) across the study area, an increase of 203 %. This translates to a dead tree density of 45 trees per hectare, up from 15. Though the largest increases were in the smaller size classes, standing dead trees greater than 31 cm dbh made up 9 percent of the total. Black and scarlet oak were the most common species in terms of number of dead trees, followed by white oak. The number of live overstory trees increased slightly as smaller trees grew into the size class. Densities of 388 stems per hectare rose to 418 stems/ha. The top 7 most numerous tree species (Table 2) maintained their respective positions with small increases in dbh and basal areas.

Increased tree mortality is a common by product of prescribed burning, but it was expected to be confined to the smaller size classes. From visual inspection, many of the larger diameter trees that died were the result of fires that entered existing wounds such as cavities and hollow trees. Trees on exposed slopes and at the heads of draws and ridges where fire intensity was greatest were most prone to be killed.

Midstory woody plants (4 – 11 cm dbh) were reduced 28% from 18,032 to 12, 967 stems (Table 4). Though most species were reduced, the white oak family decreased by smaller percentages than red oak family species. Shortleaf pine mortality was intermediate between the white and red oaks. Flowering dogwood, the most common midstory tree, is fire intolerant and was reduced by 1/3. Extensive resprouting occurred, but continued to be killed by repeated fires. Many flowering dogwood stems remaining show major fire scars and are expected to be killed during future burns. Serviceberry (*Amelanchier arborea*) and carolina buckthorn (*Rhamnus caroliniana*), also thin barked, fire intolerant species were reduced in the midstory by 80 and 94 percent respectively.

The understory, with woody stems less than 4 cm dbh was reduced dramatically from 13,002 to 6,891 (47%). Flowering dogwood and serviceberry, fire intolerant species that took major reductions in the midstory, were reduced by 76% and 98% respectively (Table 5). Carolina buckthorn, which was nearly eliminated from the midstory, was reduced by 34%, less than the average. Resprouting by midstory stems accounts for much of the smaller woody stems. Most species were reduced. The mortality or at least top kill of this size class is enhanced due to the small stem diameter and thin bark which increases the availability of the stem cambium to direct heat mortality.

Early successional species such as sassafras, persimmon and redbud actually increased in the understory by 27%, 63% and 201% respectively. Their high resprouting potential and rapid growth rates of young stems allows them to take advantage of the removal of leaf litter and reduced competition from other species as a result of the burns.

Seedling woody plant stems increased following the applications of fire and resultant removal of leaf litter. Total stems increased 32% from 15,160 to 20,014 (Table 6). The fire intolerant species such as flowering dogwood, serviceberry, and Carolina buckthorn lost seedling densities by 34%, 28%, and 69% respectively. The early successional species of sassafras, persimmon and redbud exploded in the seedling layer with increases of 256%, 154%, and 43% respectively. Oak and hickory species also showed increased seedling numbers.

The ground layer was still dominated by hardwood leaf litter (Table 7) at 63%, but was down 30% from pre-treatment conditions. With the reduction in leaf litter cover as a direct effect of the burning came a corresponding increase in bare ground and exposed rock which increased to 7% and 18% respectively. Non-woody vegetation increased at the same time woody vegetation decreased in relative abundance and cover (Table 8) in the post treatment. However, while trees and shrubs in the ground layer decreased slightly in frequency as would be expected, their foliar cover actually increased 15%. But due to the dramatic increases in cover and frequency made by herbaceous species, the relative importance of the trees and shrubs decreased. The biggest increases post treatment were made by legumes, grasses, and sedges with legumes increasing from 19% to 30% of the total foliar coverage. The two most common legumes, bare-stem tick trefoil and hog peanut increased fivefold in cover.

Diversity increased slightly from 11.5 to 12.2 taxa per quadrat and from 465 to 482 total taxa occurring in the 4000 m² sampled. Since this is a perennial dominated vegetation, most of the changes in relative importance has resulted from the general fire susceptible nature of small woody plants, the re-sprouting from the base of larger woody stems top killed by fire, and the rapid spread in new vegetative growth from established herbaceous perennial species such as the native legumes. Glade and creek bottom plots continued to average 30+ taxa per quadrat. Much of the increase in diversity is from a low to moderate level of increase across a broad suite of acid upland woods plots

The largest changes in relative importance rankings (Table 9) came from woody species declining with fire, carolina buckthorn, mockernut hickory and flowering dogwood, and herbaceous species increasing with the rapid spread of creeping roots, woodland sunflower (*Helianthus hirsutus*) and a bush clover (*Lespedeza intermedia*). Grasses such as bosc's panic grass (*Panicum boscii*) as well as most of the sedges increased with much less speed as they more slowly take advantage of exposed bare ground to establish seedlings from seed. Herbaceous species clearly have a competitive advantage in the post-treatment frequent fire environment. The number of herbaceous species in the top twenty RIV increased from five to nine.

Initial increases in ground layer vegetation were observed in the summers of 1998 and 1999 with a flush of opportunistic native annual species such as fireweed (*Erectites hieracifolia*) but the abundance of these annual species declined by the 2001 sampling season.

5. Conclusions

These results indicate a landscape in transition. The woody mid and understory that developed in the absence of disturbance, fire, has been reduced. The overstory, which does not replicate the historical records of the area, persists due to the fire tolerant nature of larger trees. This long term management scenario of periodic fires is expected to continue the

increased rate of overstory tree mortality which will allow more sunlight penetration to the ground and provide the opportunity for formation of a more open and biologically diverse landscape.

Fires continue to stimulate flowering and seed production in perennial grasses, sedges and to create bare ground for seedlings to be established. Herb seedling establishment in the rocky and excessively drained soils of this basin is slow. Highly acidic soils make nutrient availability a limiting factor in the rate of herbaceous establishment and growth. It is expected that the trends established in this first five years will continue and the typical upland woods plot will change from a low diversity (measured at the meter quadrat scale) woody seedling dominated vegetation to a moderate diversity broadleaf herb and graminoid dominated vegetation. It is reasonable to expect this change to take a couple decades of frequent fire to reach a new stable composition rather than merely a few years of fire. Structural conditions can be changed rapidly and maintained with a regime of recurring fire, but change to a stable and more diverse composition under this fire regime will need much more time and fire.

TABLE 2: Most Numerous Live Tree Species – Chilton Creek Study Area, 1997 – 2001

SPECIES	Density*		Diameter Breast Height**		Basal Area ***	
	1997	2001	1997	2001	1997	2001
All Species Recorded (43 species)	387.6 (156.5)	417.8 (168.8)	20.7 (8.4)	21.2 (8.6)	13.0 (28.7)	14.7 (31.6)
White Oak *Quercus alba*	92.8 (37.5)	101 (41.0)	19.0 (7.8)	19.5 (7.9)	2.7 (6.4)	3.0 (7.0)
Black Oak *Q. velutina*	73.4 (29.7)	76.7 (31.0)	24.3 (9.8)	24.9 (10.1)	3.4 (6.4)	3.7 (6.8)
Scarlet Oak *Q. coccinea*	56.5 (22.8)	58.7 (23.7)	22.3 (9.0)	23.4 (9.5)	2.2 (4.5)	2.5 (4.9)
Pignut Hickory *Carya glabra*	31.7 (12.8)	33.6 (13.6)	19.3 (7.8)	19.6 (7.9)	0.9 (2.2)	1.0 (2.3)
Mockernut Hickory *C. tomentosa*	24.4 (9.9)	25.9 (10.5)	19.4 (7.8)	19.4 (7.8)	0.7 (1.7)	0.8 (1.8)
Shortleaf Pine *Pinus echinata*	23.3 (9.4)	25.4 (10.3)	22.3 (9.0)	22.7 (9.2)	0.9 (1.9)	1.0 (2.1)
Post Oak *Q. stellata*	21.5 (8.7)	23.4 (9.4)	21.7 (8.8)	21.9 (8.9)	0.8 (1.7)	0.9 (2.0)

***Density Units-stems/HA (Stems/AC)**
****DBH Units = cm (in)**
*****Basal Area Units = M^2/HA (Ft^2/AC)**

TABLE 3: Dead trees by size class – selected species – Chilton Creek Study- 1997-2001.

SPECIES	SIZE CLASS *											
	Total		11–16 CM		17-21CM		22-26 CM		27-31CM		>31CM	
	1997	2001	1997	2001	1997	2001	1997	2001	1997	2001	1997	2001
All Spp (24) (Change%)	744	2,257 (203)	304	1,224 (303)	146	419 (187)	113	246 (118)	82	164 (100)	99	204 (106)
Black Oak	239	685 (186)	71	292 (311)	47	125 (166)	42	95 (126)	39	89 (128)	40	84 (110)
Scarlet Oak	142	446 (214)	77	252 (227)	24	88 (267)	13	38 (193)	11	23 (109)	17	45 (165)
White Oak	68	284 (317)	34	193 (468)	8	38 (375)	12	23 (92)	6	10 (67)	8	20 (150)
Blackjack Oak – *Q. marilandica*	46	115 (150)	9	32 (256)	15	33 120)	10	25 (150)	6	14 133)	6	11 (83)
Post Oak	34	86 (153)	14	45 (221)	3	14 (367)	4	6 (50)	4	7 (75)	9	14 (56)
Shortleaf Pine	23	81 (252)	8	49 (513)	6	16 (167)	3	10 (233)	2	3 (50)	4	3 (-25)
Flowering Dogwood *Cornus florida*	11	87 (690)	10	77 (670)	1	9 (800)	0	1 (100)	0	0	0	0

***English Units = Total ; 4.5-6.5 inches; 6.6-8.5 inches; 8.6-10.5 inches; 10.6-12.5 inches; 12.5+ inches**

TABLE 4: Midstory (4-11 cm dbh) mortality – selected species – Chilton Creek Study, 1997 – 2001

SPECIES	NO. STEMS		DIFFERENCE	CHANGE (%)
	1997	2001		
All Species (74)	18,032	12,967	- 5,056	28
Flowering Dogwood	4,488	3,038	- 1,450	32
White Oak	3,370	2,633	- 737	22
Pignut Hickory	1,646	1,115	- 531	32
Mockernut hickory	1,156	971	- 185	16
Black Gum (*Nyssa sylvatica)*	1,002	989	- 13	1
Black Oak	781	530	- 251	32
Scarlet Oak	765	366	- 399	52
Sassafras (*Sassafras albidum*)	679	301	- 378	56
Post Oak	603	431	- 172	29
Red Maple (*Acer rubrum*)	402	346	- 56	14
Winged Elm *(Ulmus alata)*	386	311	- 75	19
Shortleaf Pine	274	186	- 88	32
Carolina Buckthorn *(Rhamnus caroliniana)*	225	13	-212	94
Serviceberry *(Amelanchier arborea)*	122	25	-97	80
Blackjack Oak	111	44	- 67	60

TABLE 5: Understory (< 4 cm) mortality – selected species – Chilton Creek Study, 1997 – 2001

SPECIES	NO. STEMS		DIFFERENCE	CHANGE (%)
	1997	2001		
All Species (96)	13,002	6,891	- 6,111	47
Flowering Dogwood	2,682	635	- 2,047	76
White Oak	937	403	- 534	57
Sassafras	871	1,102	+ 231	27
Red Maple	721	207	- 514	71
Black Gum	672	292	- 380	57
Mockernut Hickory	565	239	- 326	58
Pignut Hickory	532	125	- 407	77
Carolina Buckthorn	515	338	- 177	34
Serviceberry	455	9	- 446	98
Winged Elm *Ulmus alata*	327	118	- 209	64
Black Oak	323	217	- 106	33
White Ash *Fraxinus americana*	257	79	- 178	69
Scarlet Oak	220	83	- 137	62
Red Elm *U. rubra*	192	37	- 155	81
Persimmon *Diospyros virginiana*	163	266	+ 103	63
Redbud *Cercis canadensis*	143	431	+ 288	201
Post Oak	129	62	- 67	52

TABLE 6: Seedling woody plants – selected species – Chilton Creek Study, 1997 – 2001

SPECIES	NO. STEMS		DIFFERENCE	CHANGE (%)
	1997	2001		
All Species (52)	15,160	20,014	+ 4,854	32
Sassafras	1,197	4,263	+ 3,066	256
Red Maple	1,781	2,696	+ 915	51
White Oak	1,345	1,480	+ 135	10
Flowering Dogwood	1,661	1,090	- 570	34
Winged Elm	495	891	+ 396	80
Black Oak	764	875	+ 111	15
Black Hickory *C. texana*	230	803	+ 573	249
Black Gum	437	756	+ 319	73
Red Elm	686	718	+ 32	5
Post Oak	546	714	+ 168	31
Carolina Buckthorn	1,975	608	- 1,367	69
Pignut Hickory	357	583	+ 226	63
Persimmon	183	465	+ 282	154
Mockernut Hickory	300	440	+ 140	47
Scarlet Oak	180	375	+ 195	108
White Ash	533	368	- 165	31
Redbud	250	357	+ 107	43
Shortleaf Pine	65	164	+ 99	152
Serviceberry	54	39	- 15	28

TABLE 7: 1 M² Quadrat Summary – Chilton Creek Study, 1997 – 2001

Attribute	Mean cover (%)		DIFFERENCE	CHANGE (%)
	1997	2001		
Foliar Vegetation	15.5	23.7	+8.2	+53
Litter (leaf, needle, grassy)	89.6	63.2	-26.4	-30
Bare Ground	0.66	7.62	+6.96	+1054
Rock	4.24	18.3	+14.1	+332
Down Dead Wood	3.20	9.56	+6.36	+199
Moss and Lichens	1.48	2.47	+0.99	+67

TABLE 8: 1 M² Quadrat Vegetation Physiognomic Summary – Chilton Creek Study, 1997 – 2001

Physiognomic Type	Frequency/ Cover		RIV 200		RIV DIFFERENCE	RIV CHANGE (%)
	1997	2001	1997	2001		
Tree and Shrub	14,254/ 29,917	12,545/ 34,276	38.51	29.11	-9.4000	-24.41
Broadleaf Forbs (excl. legumes)	13,535/ 10,100	14,645/ 17,501	22.50	23.30	+0.8000	+3.5556
Legumes	6,140/ 12,654	7,929/ 31,784	16.41	23.20	+6.7900	+41.377
Woody Vine	5,061/ 5,373	4,977/ 6,993	9.64	8.41	-1.2300	-12.76
Grass	3,499/ 3,993	4,943/ 10,188	6.88	9.90	+3.0200	+43.895
Sedge	2,794/ 1,787	3,313/ 3,078	4.42	4.85	+0.4300	+9.7285
Fern and Allies	616/ 1,265	476/ 1,579	1.64	1.24	-0.4000	-24.39

TABLE 9: 1 M² Quadrat Vegetation Top 20 Relative Importance Values – Chilton Creek Study, 1997 – 2001

Rank	1997			2001		
	Species	Rank Change	RIV	Species	Rank Change	RIV
1	**bare-stemmed tick trefoil** *Desmodium nudiflorum*	-1	6.61	**hog peanut** *Amphicarpa bracteata*	+2	10.15
2	**sassafras** *Sassafras albidum*	-1	4.61	**bare-stemmed tick trefoil** *Desmodium nudiflorum*	-1	6.00
3	**hog peanut** *Amphicarpa bracteata*	+2	4.54	**sassafras** *Sassafras albidum*	-1	5.21
4	**flowering dogwood** *Cornus florida*	-8	3.44	**bosc's panic grass** *Panicum boscii*	+12	3.48
5	**white oak** *Quercus alba*	-1	3.13	**summer grape** *Vitis aestivalis*	+5	2.29
6	**virginia creeper** *Parthenocissus quinquefolia*	-2	2.53	**white oak** *Quercus alba*	-1	2.13
7	**black oak** *Quercus velutina*	-6	2.19	**black-edged sedge** *Carex nigromarginata*	+4	1.87
8	**late low blueberry** *Vaccinium vacillans*	-1	2.17	**virginia creeper** *Parthenocissus quinquefolia*	-2	1.68
9	**carolina buckthorn** *Rhamnus caroliniana*	-23	1.94	**late low blueberry** *Vaccineum vaccilans*	-1	1.46
10	**summer grape** *Vitis aestivalis*	+5	1.88	**red maple** *Acer rubrum*	+3	1.44
11	**black-edged sedge** *Carex nigromarginata*	+4	1.79	**aromatic sumac** *Rhus aromatica*	+1	1.39
12	**aromatic sumac** *Rhus aromatica*	+1	1.72	**flowering dogwood** *Cornus florida*	-8	1.39
13	**red maple** *Acer rubrum*	+3	1.65	**black oak** *Quercus velutina*	-6	1.36
14	**mockernut hickory** *Carya tomentosa*	-14	1.62	**woodland sunflower** *Helianthus hirsutus*	+35	1.31
15	**black cohosh** *Cimicifuga racemosa*	-1	1.54	**black hickory** *Carya texana*	+13	1.30
16	**bosc's panic grass** *Panicum boscii*	+12	1.51	**black cohosh** *Cimicifuga racemosa*	-1	1.10
17	**post oak** *Quercus stellata*	-6	1.31	**long-awned wood grass** *Brachyelytrum erectum*	+5	1.07
18	**pignut hickory** *Carya glabra*	-8	1.28	**saw greenbriar** *Smilax bona-nox*	+1	1.02
19	**saw greenbriar** *Smilax bona-nox*	+1	1.26	**hairy wood violet** *Viola sororia*	+4	0.98
20	**deerberry** *Vaccinium stamineum*	-10	1.24	**wandlike bush clover** *Lespedeza intermedia*	+44	0.96

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