

Management of Degraded Oak Savanna Remnants In the Upper Midwest Preliminary Results From Three Years of Study

Steven I. Apfelbaum
Applied Ecological Services
Brodhead, Wisconsin

Alan Haney
College of Natural Resources
University of Wisconsin – Stevens Point
Stevens Point, Wisconsin

Written 1987

Abstract

With several collaborators, we initiated studies in 24 remnant oak savannas in northern Illinois, Indiana, and southern Wisconsin. Vegetation and soil data will be ordinated in all studies, but we report here preliminary results of fire management studies. In small tracts, vegetation was compared before and after controlled burns. Larger tracts were divided into fire treatments in addition to comparison of vegetation before and after fire. Additionally, small mammal and breeding bird inventories were taken in four savannas. Leaf litter insects were studied in two, and lichens and bryophytes were investigated in three savannas. Trees were cored in most savannas to determine community age structure. Fire, by all indications, is a major factor in establishment and maintenance of oak savannas. Although a moisture continuum exists from dry oak savannas dominated by black oak to mesic oak savanna with swamp white oak and bur oak, all have burned periodically. Light fire may have occurred nearly every year in dry savannas, but age distribution of trees in distinct cohorts suggests that periodic, intense fires were interspersed with several years of light or no fires, during which time canopy cohorts were recruited. In all instances, controlled fire has reduced the number of exotic or mesic species and favored occurrence of prairie and savanna associates. As shrubs and mesic trees are reduced, the herbaceous ground cover layer increases in cover and species richness. Periodic fire appears to favor richness of birds, insects, and spiders. We believe frequent to moderate fires usually are necessary for several years to restore savannas. Thereafter, less-frequent burning, with an occasional hot fire interspersed with a 5-10 year gap, may be essential to recruit new cohorts for the canopy and to maintain savanna species.

Introduction

Most research on oak systems has had a silvicultural focus. In the Midwest, research has not yet produced answers to basic questions regarding oak regeneration. Natural area biologists recently have developed a more defined concept of the presettlement nature of oak systems, including definitions for oak savanna systems (Anderson 1982, 1983, Nuzzo 1986, Packard 1986). In 1986 and 1988, oak-system workshops resulted in an exchange of information between these two lines of inquiry (McGraw Wildlife Foundation 1986, Oak Woods Workshop at Bradley University 1988).

In 1986, a cooperative research program was initiated in northern Illinois to investigate the existing condition and restoration potential for oak savannas. Pre-sampling of regional oak savanna remnants suggested a high degree of within- and between-site variability for vegetation and soil parameters. Vegetation variance was related to site history and physiography. Because of variation

between study sites, sample sizes were increased and additional sites, with better documented site history, were added. We provide an overview of preliminary findings at several sites and some general conclusions. Response to management treatments is presented for a silt clay loam soil savanna in northern Illinois, and for a sand savanna in northern Indiana.

Our purposes were to (1) quantify existing conditions of savanna remnants in regionally representative physiographic settings; (2) establish a monitoring capability that facilitates statistical comparisons of meaningful baseline parameters to change with continued non-management, and those in sites managed with a variety of aggressive strategies, including controlled burning shrub and tree removal, and seed introduction; (3) allow for determination of optimal management regimes to restore savanna communities; and (4) establish an initial study of cooperative savanna research within the region and stimulate more inquiry on the savanna ecosystem.

Methods

Study site selection: Twenty-four areas from northwestern Indiana through northern Illinois and into southern Wisconsin were included in this study. All study sites were oak-dominated savanna communities. Study sites were chosen to represent major variation in soil types, oak canopy types, and hydrologic settings in the region. Sites included sand, loess, and silt-clay soils in both poorly drained and well drained sites. Additional goals and criteria for choice of study locations included:

- (1) Ownership and protection – remnants included in this study were largely in public ownership and available for restoration or experimental management.
- (2) Management – committed site stewards and managers were a prerequisite to implement experimental management and restoration strategies for this research program.
- (3) Recent History – study sites were variously graded or burned, but none were timbered recently.

Research: We sampled woody and herbaceous vegetation at all sites, while lichens, bryophytes, ground litter invertebrates, butterflies, leafhoppers, breeding birds, and small mammals were sampled in one or more of the savannas. Soil characteristics and surface hydrology also were described or measured. We compiled site histories based on available literature, interviews with knowledgeable persons, land survey records, and tree ring analysis. A related study of drought frequencies was conducted using dendrochronological methods in one savanna. Here we focus on general results of vegetation studies.

Vegetation at all sites was sampled along stratified random transects that completely bisected the savanna remnants. Data for woody vegetation included canopy intercept, numbers and diameters for trees, and shrub densities. Trees were cored by representative size-classes for tree species to determine age distributions. Basal area for woody stems over 2m tall were estimated by prism samples along transects at 25 m intervals. Cover and frequency of herbaceous vegetation was estimated with 1 m² quadrats at 10 m intervals along each transect.

Results and Discussion

Degradation of Black-Soil Savannas

Presettlement black-soil savanna systems had canopies that varied from nearly closed to as open at 10% canopy cover (Moran 1978, 1980, Hanson 1978). Ground cover was diverse, reflecting subtle hydrological gradients within each site. It is difficult to identify a distinct black oak savanna community because of the rich mosaic of wet swales, often with some seasonal aquatic communities, and upland mesic to dry open habitats including prairie. The term “tall grass savanna” may be appropriate to characterize the complex mosaic that probably was represented by the presettlement savanna system on

deep silt clay loam soils. Savannas on shallow silt clay loams and other soil types were distinct and warrant additional considerations.

Based on our studies, early in the last century heavy livestock grazing and logging acted to begin a process of savanna degradation (Fig. 1). At that time, suppression of wildfire regimes, drainage for agriculture, and land development acted to further the degradation process. We hypothesize that livestock grazing reduced ground cover plants, especially in locations where grazing was persistent for many decades. Many savannas were grazed, timbered, and then cleared for agriculture. After heavy logging, and in the absence of fire, a flush of regrowth developed. Continued grazing reduced regrowth and ground cover, and new forests eventually developed that differed from original savanna, reflecting site conditions and history.

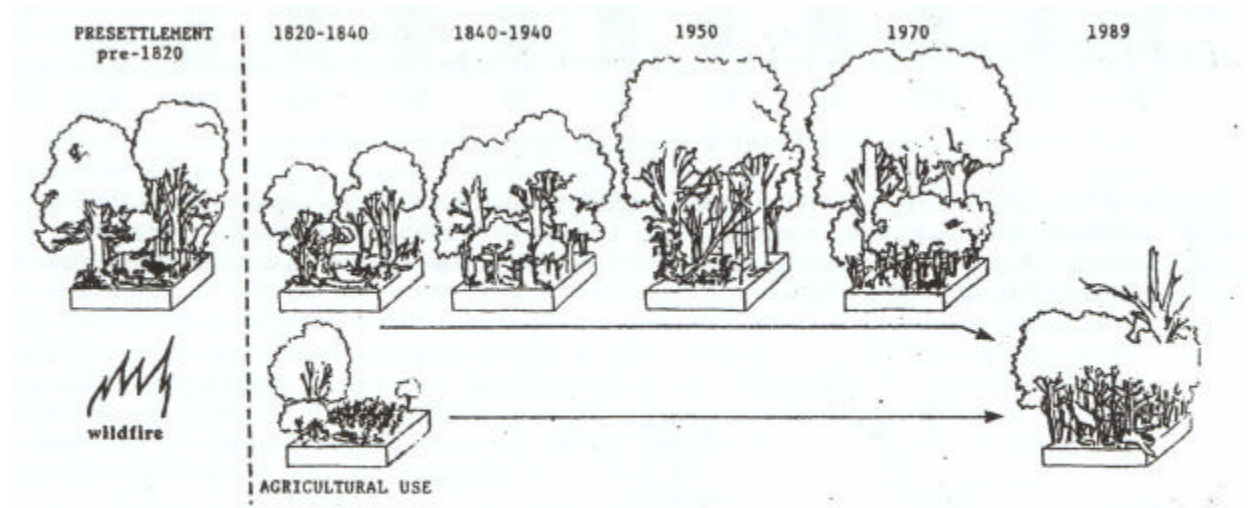


Figure 1. Generalized trends in the degradation of tall grass (black-soil) savanna vegetation. Based on investigations 1986–1988 in savanna remnants of northern Illinois. See text for descriptions.

In the Chicago region in the 1970's, several exotic shrubs, including common buckthorn (*Rhamnus cathartica*), and Tartarian honeysuckle (*Lonicera tatarica*) became widespread in oak savanna remnants. Oak savanna remnants with canopy intercepts of 40-80% may have been the most vulnerable vegetation types to buckthorn invasion (Fig. 2). Invasion by exotic shrub species contributed to dense shading that has resulted in the loss of savanna ground cover species. Canopy oaks are now showing increasing mortality, while oak seedling regeneration beneath the dense shade is poor to absent in most study sites. In several study areas canopy oaks are nearly gone and a dense understory of 5-8 m buckthorn shades virtually bare ground. Buckthorn stands also have developed on some presettlement savanna sites that were cleared, farmed, and then fallowed. Typically, these sites were clearings in larger oak savannas. Both vegetation and avian studies (Emlen 1971) reveal significant declines in native plant and breeding bird species richness with degradation of the tall grass savanna (Fig. 3).

Average % Buckthorn Cover

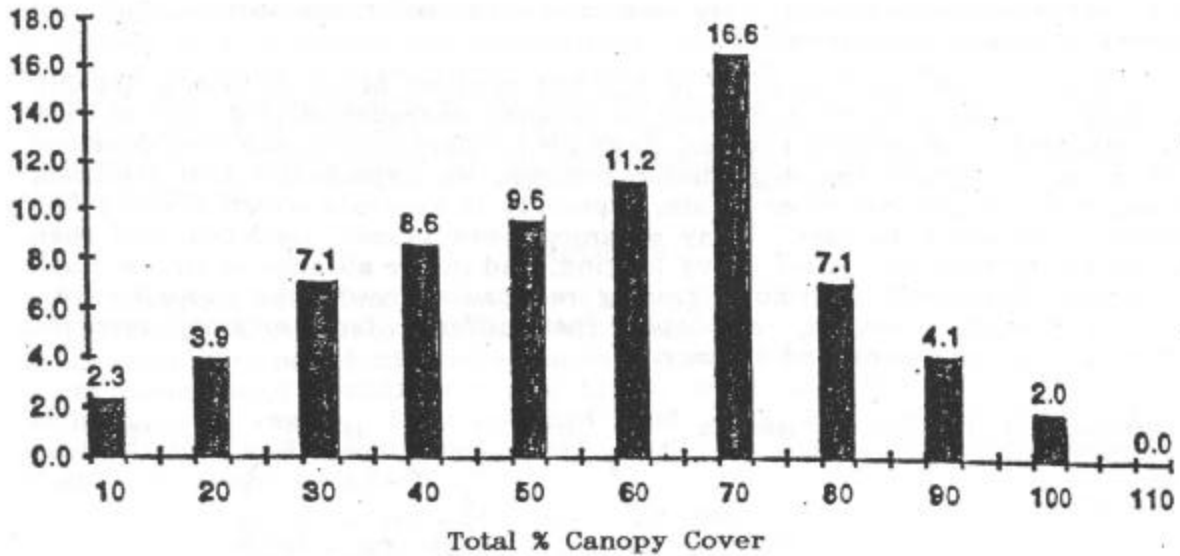


Figure 2. Relationship between mean percent intercept of European Buckthorn and percent intercept of canopy oak trees. Based on average intercept calculations from 50 m transects segments (n=143) in tall grass savanna remnants of northern Illinois, 1986-1987.

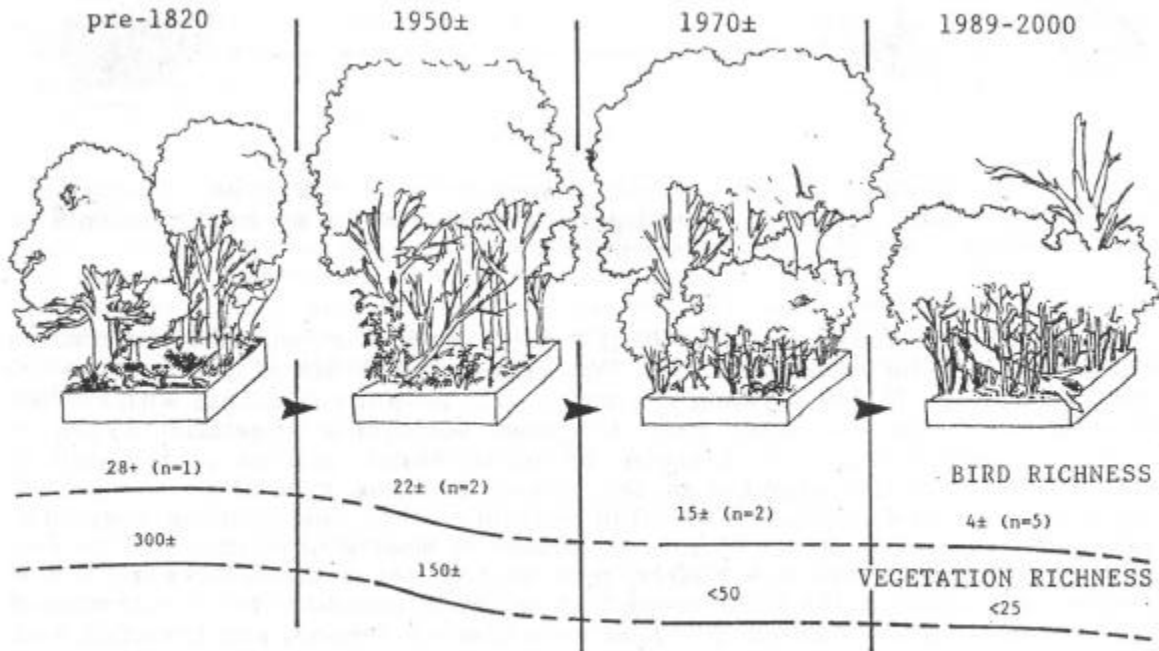


Figure 3. Summary of several major trends associated with the degradation of tall grass savanna. Based on avian and vegetation studies in tall grass savanna remnants in northern Illinois, 1986-1987.

Status of Sand Savannas

In the absence of fire, basal area, cover, and density of woody plants, primarily oaks, sassafras, aspen, and several native shrubs, were measured in remnant Indiana sand savannas. Where grub-form oaks (shrub-like annual growth from older root stock) historically dominated, 5-10 m tall single and multistemmed tree-form oaks now grow. Increased shade is associated with reduced herb layer cover and richness; however, even with livestock grazing, a rich vegetation usually remains in sand savanna remnants. Unlike black-soil savannas, sand savannas have been much slower to close in the absence of fire and invasion of exotic species is less common.

Woody Plant Structure and Recruitment

Savanna remnants contained widely scattered dominant oaks that were 80-250 years old. Most communities, when fire or grazing had been excluded, developed heavy understories of more mesic, younger trees and shrubs. Recruitment of oaks, in virtually all instances, ceased with the establishment of a mesic understory. This agrees with observations and conclusions of McCune and Cottam (1985).

Studies in old growth deciduous forests clearly suggest that catastrophic disturbance episodes are largely responsible for oak recruitment (Hough and Forbes 1943, Henry and Swan 1974, Tubbs 1977, Lorimer 1980, Runkle 1982). Fire scars were present on most older oaks in all savanna remnants we studied. Exclusion of fire and grazing would be expected to lead to invasion of mesic trees and shrubs which, in turn, would reduce recruitment of oaks. Nowacki (1988) developed a similar hypothesis to explain age structure and composition of northern red oak communities in north-central Wisconsin. If fire events were responsible for oak savannas, we hypothesized that the age of oaks should (1) be present in cohorts that reflect periodic recruitment and, (2) age of the youngest cohort should correspond to the oldest mesic trees in the understory and to the time when fire or grazing was excluded.

Examination of woody plant reproduction revealed that virtually all oaks in the herb layer (less than 1 m tall) were sprouts from large root "grubs" of unknown age. In some instances, we found a few seedlings less than a year old. The major recruitment pool for oaks, therefore was comprised of sprouts from established root systems.

Trees in most remnants were cored to determine age. In all instances, oaks fell into distinct cohorts. In the simplest oak community (a white and red oak savanna on silt loam soil in Illinois), two cohorts of oaks were present: one group 230-250 years old, and a second 135-150 years old. Size of trees for each species in both cohorts completely overlapped, and ranged from 12-38 inches d.b.h. Beneath the oaks was a 25 year-old cohort of black cherry. Intense grazing was discontinued 25 years prior to our study.

In the most complex community examined, four cohorts were 230-250 years (1758-1738), 100-140 years (1868-1888), 50-90 years, and less than 25 years of age. This savanna was on black soil in a Chicago suburb and had the richest associated savanna flora found.

Results of age analysis suggest that recruitment of oaks to the savanna canopy is related to periodic events that may occur only once in 35-100 years. We believe that these recruitment events are fire-related, and some are related to climatic patterns. In an unpublished study of bur oak dendrochronology at The Grove National Historic site in Glenview, Illinois, Sheppard and Cook (1986) concluded that there was a distinct dry period from 1860-1840. The beginning of this dry period corresponds to the age of the 230-250 year cohort present in many oak savanna remnants we studied in the region. The end of this dry period corresponds to the age of the 130-150 year cohort that occurs here (Fig. 4).

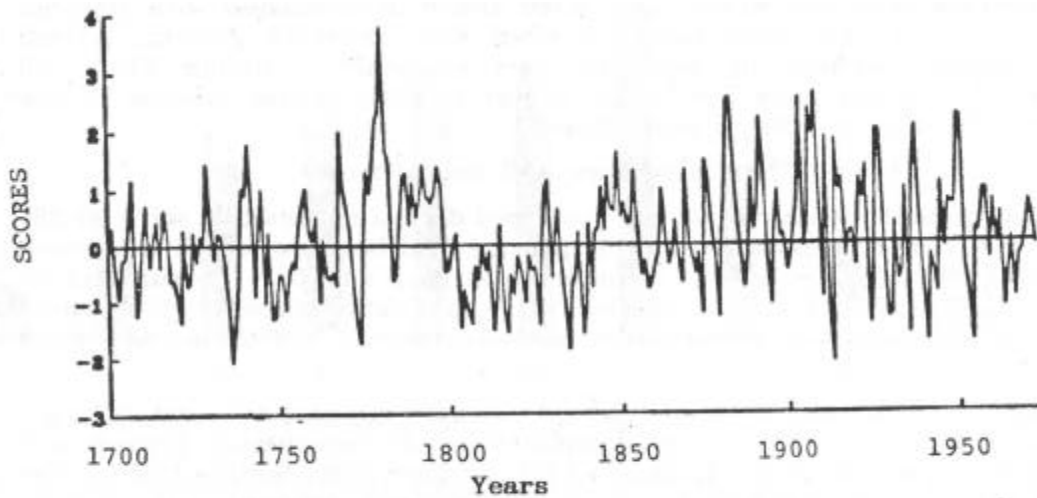


Figure 4. Regionally reconstructed summer drought series. Positive scores represent relatively wet conditions and negative scores represent relatively dry conditions. Taken from Sheppard and Cook (1986). Based on bur oak (n=13) dendrochronology research at the Grove National Historic Landmark, Glenview, Illinois.

Although more dendrochronology studies are needed to evaluate this model, we believe that frequent wild fire maintained savanna by suppressing establishment of mesic species and continual recruitment of oaks that would result in all-aged forests with multiple-structured layers. “Windows” of opportunity occurred when, during wetter periods, fires were less common or intense for 10-30 years, allowing growth of grub sprouts to reach a size when they no longer would be killed by an average or less-intense fire. Longer recruitment “windows” were required on drier sites that tended to burn easier, hotter, and more often.

Implications of this hypothetical model for management are important. Prescribed fire should be used annually, or at least once every two or three years, with hotter fires on drier sites, until most recently established species are eliminated. Often this will result in establishment of associated savanna ground cover species, although reseeding sometimes is necessary (Packard 1986). Once the primary community has been achieved, 10-20 year “windows for recruitment” should be planned during which intense fire is withheld. The decision to recruit another oak cohort by excluding intense fire should be based on desired density and structure of trees in the community (land surveyor records and historic aerial photographs may be useful to determine goals).

Tefft Sand Savanna

The Tefft Savanna (Jasper and Pulaski Counties, Indiana) study area included 9 contiguous 40 acre blocks separated by fire breaks, all with similar anthropogenic history and stand origin. High-intensity and low-intensity prescribed burning was implemented in replicated treatments with adjacent control blocks. Study transects were established randomly in each block. Prescribed burning was conducted by the Indiana Department of Natural Resources under conditions that produced the desired intensities. Fuel loads averaged 560 g/m² before fire; one year after fire, fuel loads ranged from 400-650 g/m² in areas burned with either low-intensity or high-intensity fire.

With intense fire, shrub (<2 inches d.b.h.) cover was reduced 65% and sapling (>2 inches d.b.h.) cover was reduced 38%. Larger oaks (>4 inches d.b.h.) had 26% less cover with hard burning and no significant change with low-intensity prescribed burning. In contrast, a decline of 62% and 42% in canopy intercept was measured for non-oak trees for high- and low-intensity fires, respectively.

Sensitivity of woody plants varied by species and burn intensity. Oaks, sassafras, and big-toothed aspen showed significantly less susceptibility to light burning than did such other species as black cherry, willows, red maple, or quaking aspen. Woody plant mortality, as measured by top kill, was significantly higher with hard burning. Size-class frequency distributions were skewed significantly by burn intensity. Large trees generally survived, whereas smaller trees were top-killed with high-intensity burns.

Richness of herbaceous and graminoid vegetation increased by 36% and 28% with hard and light burning compared to unburned controls. Herbaceous and graminoid cover and frequency values increased by 40% and 37% with high- and low-intensity burning, respectively. All changes were significant ($P < .05$).

Reed Turner Silt-Clay Loam Remnant

The Reed Turner Nature Preserve (Long Grove, Illinois) was divided into 4 study units and each area was divided into burn and control (no burn) zones. Burn and control areas were compared for herbaceous and woody vegetation before (1986) and after two prescribed burns. Fuel loads before fire varied from 550 g/m² in closed forests to 725 g/m² in degraded open savanna. Woody vegetation response to the autumn 1986 burn was as follows:

- (1) Small (0-2 inch) diameter stem density increased dramatically the first season after burning because of root and stump sprouting of top-killed 1-2 inch diameter saplings and shrubs. Based on averages per tree stem, sprouting rates in burned compared to unburned controls include black cherry with an 80-fold increase, choke cherry (100%), and common buckthorn (30x).
- (2) Shrub-sized plants of *Crataegus* spp., Choke Cherry, and *Viburnum* spp. were all top-killed by fire, and survived by sprout recovery. All other tree and shrub species suffered some mortality, but at least some stems survived the fire.
- (3) Larger stems (>2 inches) showed little initial response to fire, either in mortality or sprouting. Oak saplings and larger stems apparently were not effected, whereas roughly 10% percent of 0-4 inch diameter stems of basswood, buckthorn, and Black Cherry were top-killed, with only a few survivors.

Overall response of ground cover vegetation in closed-canopied woodlands at Reed Turner to the autumn 1986 burning involved a 10% increase in richness; 16 species were present after fire compared to pre-burn data. Slightly more than 40% of the species remained stable, with no significant change in cover or frequency before and after burning. Six species decreased substantially (>50%) in importance value and 12 species were completely absent after the fire. Those decreasing included seedlings of white ash, choke cherry, common buckthorn, and wild black currant. Absent after burning were seedlings of less abundant woody plants such as *Crataegus mollis*, and several species only encountered once in 111 sample quadrats. Species that increased were those generally associated with more open conditions, including *Anemonella thalictroides*, *Arisaema triphyllum*, *Camassia scilloides*, *Carex Pennsylvanica*, *Geranium maculatum*, *Rhus radicans*, *Trillium recurvatum*, *Viola* spp., *Vitis* spp., and *Taraxacum officinale*.

After prescribed fire in the open savanna at Reed Turner Preserve, 18 species appeared and 14 species disappeared. Nearly 50% of all ground cover species showed little response (less

than 25% value change) as measured by importance value when comparing pre-burn 1986 and post-burn 1987 data. Species that had large increases in importance values (Greater than 50% change) after fire included some grasses and sedges, and False Solomon's Seal (*Smilacina* spp.). Ground cover species with large decreases (a 25% or more change) in importance value included *Poa pratensis*, *Taraxacum officinale*, and White ash seedlings. A net gain of five ground cover species was measured after introduction of fire.

Conclusions

1. Cohort recruitment of dominant woody plants appeared to result from release of sprouts from established root systems during periods of no fire.
2. We believe that oaks are capable of surviving long periods of time as small shrub-like plants beneath partial to heavy shade.
3. In heavy silt loam soils, herbaceous and graminoid soil seed-bank condition may be related to time due to prior release and differential longevity of species' seeds in the soil. Reintroduction of fire can result in increases in ground cover vegetation, especially for some species present prior to burning. Some species that showed immediate responses included *Smilacina* spp., *Polygonatum* spp., *Circaea quadrisulcata*, *Solidago flexicaulis*, *Solidago ulmifolia*, and *Geranium maculatum*. Some species that seemed to appear from soil seed-banks included *Onosmodium hispidissimum*, *Silene stellata*, *Galium circaezans*, *G. concinnum*, and *Taenidia integerrima*. Several sedges and grasses also seemed to respond (*Carex* spp., *Hystrix patula*, *Cinna arundinacea*, and *Elymus* spp.) but were restricted in distribution. Seed banks seemed to be more depauperate in heavy soils compared to sandy loams or moist organic substrates.
4. Intensity of prescribed fire is linked closely to release of ground cover plants. Modest release may be associated with low-intensity fires, especially spring burns. Intense fall burns have best resulted in release of ground cover vegetation, including oak seedling generation.
5. As woodlands become more open, fuel conditions become more conducive to intense fires and prescribed fire becomes more effective in savanna management.

Literature Cited

Research for this paper is based on more than 15 references of technical materials. Contact AES for the complete bibliography.