

TITLE: Assessing indicator sensitivity for monitoring the effects of fire and species reintroductions on soils and plant communities during intensive restoration of oak savannas in Central Iowa

LOCATION: Iowa **DURATION:** 3 years **FUNDING SOURCE:** Fire Plan Evaluation Monitoring

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PROJECT OBJECTIVES: This study will evaluate the use of detection monitoring (DM) indicators to quantify changes during dynamic shifts in ecosystem state from degraded to experimentally restored oak savannas.

Specific objectives include:

- (1) Continue to evaluate concurrent measurements of Forest Health Monitoring indicators and more detailed, process-level indicators of forest health (species composition/structure, soil properties, fire dynamics) in replicate degraded/restored oak savanna research areas (n = 4 degraded savannas, n = 4 savannas undergoing restoration) to assess community and ecosystem response to woody encroachment and savanna restoration (thinning, burning, reseeded) (monitoring currently supported by FHM grants 03JV11231300012 and 03JV11231300023).
- (2) Initiate experiments to evaluate ecosystem change resulting from reestablishment of native understory species through reintroduction of diverse species mixes and reimplementation of understory fire regime.
- (3) Compare assessments of ecosystem function and restoration success obtained from DM indicators to more detailed ecosystem measurements to determine their sensitivity to restoration by species reintroductions and fire.

JUSTIFICATION: The health of oak savannas of the Central Plains states is of regional concern due to low rates of oak regeneration and widespread invasion by shade tolerant tree species, both of which alter the quality, composition, structure, and ecological functions of these forested systems. Restoring degraded savannas may have important management implications for *enhancing landscape-level biodiversity*, which may have cascading effects on *regional concerns with soil and water quality*. However, monitoring information is needed on current forest conditions and the effects of restoration treatments, to guide future management decisions.

The Forest Health Monitoring (FHM) program is responsible for reporting on indicators of forest health as part of the Montreal Process Criteria and Indicators of Sustainable Forest Management. DM indicators were designed to provide an easily measured, inexpensive, and repeatable index of ecological conditions that could be monitored over time to detect trends. In order for these measurements to be successfully used, indicators must be sensitive to both natural disturbances and management practices. However, few experiments have been conducted to evaluate the effectiveness of DM indicators at detecting and quantifying changes in site conditions resulting from known disturbances and intensive management practices that *specifically implement fire*. Without direct comparison to data collected from long-term controlled experiments, it is not possible to assess the utility of DM data for use in ecological contexts (O'Neill et al. 2005).

Development of a monitoring strategy to assess the ecological responses of degraded oak savannas to restoration treatments and landscape change is compatible with the following objectives of the Fire Plan Evaluation Monitoring component of the FHM program: (1) *fire risk*, which is an important consideration when using fire for management in suburban/agricultural landscapes, (2) *influence of fire* on dynamic ecosystem states (woodland/savanna), soil properties, and species composition, (3) effective control of *invasive species* (encroaching trees), and (4) evaluating *restoration* of degraded ecosystems undergoing prescribed fire and species reintroductions.

DESCRIPTION: Savannas were once a dominant ecosystem on the Midwestern landscape, occurring within the dynamic boundary between prairies to the west and forests to the east. Savannas are maintained in the landscape by complex interactions between fire, climate, topography, and human activities and are characterized by a continuous herbaceous layer and scattered oak trees (Anderson 1998). Today, savannas are extremely rare (<1% remain after extensive conversion to agriculture; Nuzzo 1986) and persisting remnants are often highly degraded by fire suppression, over-grazing, habitat fragmentation, and subsequent invasion by native and exotic woody species (Anderson 1998, Gobster et al. 2000). Savanna restoration generally involves mechanical removal of encroaching woody vegetation and reintroduction

of fire (McCarty 1998). However, reintroduction of native understory species may also be a critical tool during restoration (Brudvig and Mabry *in review*). Without this final step, restoration efforts could fail to reestablish the characteristic herbaceous layer, which is the predominant fuel source for fire in this ecosystem (Anderson 1998).

A project was initiated in 2004 to assess the efficacy of FHM and ecosystem-process indicators to detect ecological responses to oak savanna restoration (USFS FHM grants 03JV11231300012 and 03JV11231300023). To date, short-term goals relating to restoration of overstory composition and structure have been achieved (Asbjornsen et al. 2005, Brudvig and Asbjornsen *in prep a*). However, long-term structural outcomes are unresolved (Brudvig and Asbjornsen 2005, *in prep b, c*), and reestablishment of native understory species and historic fire regime remain elusive (Brudvig *in prep*, Brudvig and Asbjornsen *in prep d*). Based on initial results from this long-term ecological study (see below), we propose that the savannas in this study have transitioned to an alternative stable woodland state (e.g., degraded condition resilient to traditional management; Suding et al. 2004), which will necessitate a second, more intensive phase of restoration. Alternative stable states commonly occur because of factors such as agricultural land-use and altered fire regime and more research is needed to understand restoration of these problematic systems (Suding et al. 2004).

We propose to expand our FHM-ecosystem study on indicators for detecting change, *by specifically investigating reestablishment of a native savanna understory and subsequent reimplementing of the historic understory fire regime*. Thus, building upon our current study, we propose to conduct a detailed analysis of soil and plant communities in our experimental savannas undergoing restoration by fire and seed sowing, *enabling us to better assess the degree of sensitivity of DM indicators to these key restoration activities*. Additionally, this study will allow us to *assess DM indicator sensitivity to major changes in ecosystem state*. Our experimental savannas are an excellent study system for this purpose, as the Midwestern landscape was historically defined by shifting mosaics of alternate stable ecosystem states (prairie, woodland, savanna; Anderson 1998). This represents a major innovation, as it will allow us to test the sensitivity of FHM monitoring in dynamic landscapes. Characterizing the utility of FHM indicators for assessing targeted research like this is a recognized priority (O'Neill et al. 2005).

b. Methods. This research is being conducted within 8 oak savanna research areas in Central Iowa, along Saylorville Lake¹. These sites are characterized by an overstory of widely dispersed, open grown savanna tree species (e.g., *Quercus alba*, *Quercus macrocarpa*), which has been aggressively invaded by younger shade tolerant species (e.g., *Ulmus americana*, *Ostrya virginiana*, *Fraxinus americana*). Experimental research areas (2.0 – 3.5 ha, n = 8) are located on upland ridge tops within a woodland/degraded savanna matrix. Restoration treatments involving removal of invading woody vegetation have been conducted on half of the areas (the others serving as controls) and prescribed understory fires will commence fall 2006. FHM survey plots have been established in all treatment and control areas following standard FHM protocol. A long-term ecological study was initiated at the same sites in 2002 to conduct detailed, process-level measurements on key indicators of forest health. Pre- and post-treatment data (vegetation in five classes: trees, saplings, shrubs, seedlings, herbaceous; soil nutrients; soil moisture) have been collected annually within 10-m wide transects running the length of each treatment and control site. This ecosystem study is linked to the FHM program through concurrent monitoring of Phase 3 indicators (understory vegetation, soils, overstory structure and growth, DWM, crowns, damage) following DM measurement protocols.

To complement the above ongoing measurements (supported by previous FHM grants), we propose to assess the ecosystem impacts of reintroducing native savanna understory species in degraded and restored savannas, based on measurements of soil properties (nutrients, organic matter, moisture), understory species composition, fuel loading, and fire dynamics. We have identified understory species of high restoration priority and suggest that by reintroducing these species, management might successfully shift these sites away from the woodland and toward the desired savanna state (Brudvig and Mabry *in review*). We propose to use a split-plot design, where main plots are the restored savannas or degraded control areas (n = 4 for each) and split-plots are 4 x 4 m plots that are either seeded with a diverse understory seed mix or remain as controls (n = 5 for each/area). To understand interactions between species reintroduction and reimplementing of the historic fire regime, we will monitor the following response variables: under-, mid-, and overstory species diversity, stand structure, fuel loading, fire intensity (using pyrometers - temperature-sensitive paints applied to metal probes), and soil properties (nutrients, organic matter, moisture). Specifically, we hypothesize that seed additions will: 1) increase diversity of understory savanna species (Brudvig and Mabry *in review*), 2) increase fuel loading and fire intensity (Rossiter et al. 2003), 3) control invasion by woody species, through direct stem mortality during fire and increased competition by the herbaceous layer (Scholes and Archer 1997), and 4) increase soil organic matter production and nutrient cycling rates (Scholes and Archer 1997). The mechanism that we propose to account for these effects is initiation of the grass/fire cycle – a positive feedback loop whereby herbaceous vegetation (predominantly graminoids and

¹ A 5,400 acre US Army Corps of Engineers flood control reservoir on the Des Moines River, 11 miles north of Des Moines, Polk County, IA.

prairie forbs; Tester 1996) is supported by frequent understory fires (D'Antonio and Vitousek 1992). Split-plots will be established within existing FHM plots, in order to correlate measurements with other ecosystem and FHM indicators. Data collected from the Phase 3 plots will be compared to data obtained from the intensive ecosystem measurements to assess differences in detection capacity of ecosystem health and response to management treatments, with an emphasis on determining the sensitivity of DM indicators to changes in fire regime and species composition. By comparing the ecosystem and FHM sampling designs, results will provide specific recommendations regarding FHM sampling protocol to enhance detection capability. Furthermore, this will provide an opportunity to understand linkages between vegetation and soil indicators during intensive ecosystem management, which is a noted research need (O'Neill et al. 2005).

c. Products. This research will provide the first evaluation of DM indicator variables in experimentally thinned, burned, and reseeded plots in oak savannas and will contribute to the development, refinement and interpretation of forest health indicators in dynamic landscapes. Results from this study will inform federal research efforts on the efficacy of FHM indicator variables and aid land managers working with fire in suburban/agricultural landscapes, reduction of invasive woody species, and ecological impacts of fire for restoring oak savannas. Findings, including a broad assessment of this project (Brudvig et al. *in prep*), will be published in peer-reviewed journals, presented at meetings (including annual posters at the FHM Working Group Meeting), and made available to land managers and scientists on FHM websites.

d. Schedule of Activities:

Year 1: Reintroduce native savanna understory species from seed. Monitor FHM and ecosystem indicators (soil, vegetation, fire). Conduct soil laboratory analyses. Initial data analyses and presentation of preliminary results.
 Year 2: Continue monitoring of soil, vegetation, and fire. Continue soil and data analyses and presentation of results.
 Year 3: Complete data collection; analysis, and comparison of FHM and ecosystem data. Publication of results.

e. Progress/Accomplishments. Based on five years of data, we find evidence for our savanna sites existing in an alternative stable woodland state. Initial restoration (removal of invading vegetation) successfully reestablished savanna structure and an oak-dominated overstory (Asbjornsen et al. 2005, Brudvig and Asbjornsen *in prep a*; species composition supported by FHM data). However, within three years, vigorous reestablishment of invading woody species had occurred (e.g., *Ostrya virginiana* and *Cornus racemosa* both returned to pre-treatment levels, Brudvig and Asbjornsen *in prep a*; further sampling of FHM plots is needed to confirm their ability to detect this result). Furthermore, restoration increased herbaceous cover from 10 to 82% (desirable in savannas), but did not result in understory species composition characteristic of oak savannas (Asbjornsen et al. 2005, Brudvig *in prep*; collection of understory species data commenced in FHM plots in September 2006 and are not yet available). Most notably, characteristic tallgrass species, such as *Andropogon gerardii* and *Sorghastrum nutans*, failed to reestablish. Without these species, restoration efforts may fail to reimplement the historic fire regime, as this group comprises an important fuel source. Together, these results suggest that the experimental savanna sites may persist in an alternate woodland state (Karnitz and Asbjornsen 2006) unless the more dramatic restoration actions described in this proposal are undertaken.

Three manuscripts have been published, 3 are in review or revision, and 9 are in preparation related to the savanna restoration research. Results have been and will continue to be presented at prominent meetings (FHM Working Group Meeting, Society of American Foresters, Ecological Society of America, World Conference on Ecological Restoration).

COSTS:

	Item	Year 1	Year 2	Year 3	TOTAL ²
Administration	MSc. graduate student assistantship; 11.5% benefits ³		\$19,513	20,098	39,611
	Out-of-state travel and expenses to Iowa study sites (L.A. Brudvig; 2 x / year)	\$1,500	1,500	1,500	4,500
	½ time Field technician (4 mo @ \$9/hr + 4.6% benefits)	3,012	3,102	3,196	9,310
Procurements	Savanna seeds (for understory species establishment)	6,000			6,000
	Pyrometers (fire intensity measurements)	2,000	1,000	1,000	4,000
	Soil analyses (nutrients, organic matter)	4,000	4,000	4,000	12,000
	Supplies (soil probes, flags, tags, etc.)	2,000	1,000	1,000	4,000
TOTAL (USFS)		18,512	30,115	30,794	79,421
Cost-Share (ISU; 50%)	H. Asbjornsen salary (10.3% FTE), Indirect costs	22,355	28,218	28,959	79,757
TOTAL (w/ cost-share)		\$40,867	58,333	59,753	158,953

² Additional support for this project is provided by the US Army Corps of Engineers (implementation of annual prescribed fires).

³ We anticipate additional funding through Iowa State University to fund the MSc. student during the first year of this study.

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* Indicates paper supported by previous USFS FHM grants for this project.



DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING - P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

Saylorville Lake Project

September 12, 2006

Dear Sirs,

I am writing this letter in support of our partners at Iowa State University and their continued research on restoration of oak Savanna's in central Iowa. Our 26000 acre project is home to significant diverse landscapes that support a wide variety of plant and animal species. Within this project are remnant ecosystems that are of particular value to protecting diversity at the project level. Remnant prairies, wetlands and oak forests all are found here; some of which we consider to be significantly sensitive areas. Oak Savanna may be our most endangered ecosystem not only at Saylorville but across the whole state. Once a very common plant community along the Des Moines river, these systems are all but unrecognizable today. Succession, invasive species and lack of fire have altered these unique ecosystems and crowded out a very diverse plant community.

Our primary management emphasis has always been related to restoration work. Our early work in Oak Savanna restoration has been to seek out historical sites and re-apply fire as a management tool. We have had some nice results alone with fire but have since branched out and started some larger scale projects. Forest treatments (weed tree removal or selective standing kill) followed by reintroduction of fire has shown even better results. Iowa State is significantly involved on the west side of our project where historic savannas are still strongly represented and have potential to restore on a much larger scale. Research and the knowledge gained will be able to assist us in our continued effort to restore. Tight budgets and manpower restrictions always promote getting the most "bang for the buck" and knowledge regarding restoration and management is key to success. Failed restorations pose a significant problem when funds and manpower are put towards a restoration and the end result falls short of expectation. The public, adjacent landowners and others become critical of failed restoration and support for programs dwindle. The importance of savanna restoration research in the infancy of restoration work in Iowa is obvious. The prairies we planted in the early 80's look nothing like the refined diverse plantings we do today. Better knowledge yields better products and Savannas are no exception.

It is our hope that the research started can continue and that valuable management biology will be the product of that research.

Scott Rolfes
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Sincerely,

STEPHEN B. FAIRBANKS
Operations Manager
Saylorville Lake Project