Bibliography of fire effects and related literature applicable to the ecosystems and species of Wisconsin. No. 187 1995

Henderson, Richard A.; Statz, Sandra H.
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Cover: Night-time fire moving through an oak woodland at The Nature Conservancy's Summarton Bog Preserve. Photo by R. Henderson.

ABSTRACT

This bibliography provides 841 literature citations pertinent to the effects of fire and its prescribed use on the ecosystems and species of Wisconsin and the upper Midwest. Three separate subject indexes are provided: one for general topics, one for species (165 headings), and one for geographic location by state or province (51 headings). The general index is divided into 8 broad subject categories, under which there are 28 topic and 58 subtopic headings. The largest subject category, and the main focus of this publication, is Effects of Fire (on soil, water, air, biota, etc.) with 11 topic headings, 41 subtopic headings, and 706 citations. The other categories are Behavior of Fire (2 topics, 5 subtopics, 78 total citations), History of Fire (4 topics, 129 total citations), Effects of Fire Regimes (6 topics, 12 subtopics, 87 total citations), Drought and Fire Interactions (5 citations), Fire Policy (12 citations), Conducting Prescribed Burns (2 topics, 11 total citations), and Other Fire Related Management (2 topics, 54 total citations). Also included is a brief and very general overview of the role of fire in Wisconsin and its effects on the ecosystems and species of the state.

Key Words: Wisconsin, Midwest, fire effects, fire behavior, fire history, water, air, soil, plants, animals, communities, litter, nutrient cycles, micro-climate, habitat, grasslands, prairies, barrens, savannas, forests, wetlands, prescribed burns.

Bibliography of Fire Effects and Related Literature Applicable to the Ecosystems and Species of Wisconsin

By Richard A. Henderson
and Sandra H. Statz

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Contents

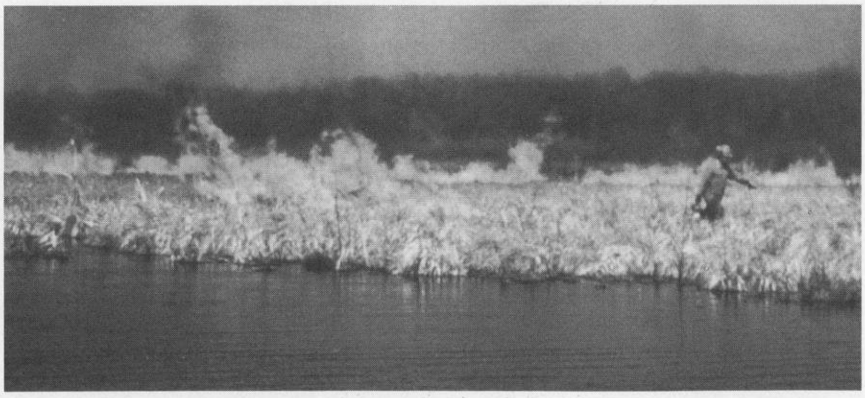
A prescribed burn to control eastern red cedar invading dry bluff prairie at The Nature Conservancy's Spring Green Preserve (April 1980).

K. HENDERSON

Prescribed fire to clear logging slash in preparation for tree planting.

DNR PHOTO

Starting a prescribed fire in a sedge meadow community at South Waubesa Wetlands State Natural Area (April 1990).



DNR PHOTO

INTRODUCTION

Fire has long played a major role in modifying and maintaining plant communities in North America (Kozlowski and Ahlgren 1974[1], Swain 1973 and 1978, Pyne 1983, Gajewski et al. 1985, Backman 1988, Anderson 1990), including much of what is now the State of Wisconsin. In fact, for the past 5 to 6 thousand years (or at least up until European settlers disrupted prevailing fire regimes), half of the state has been covered by fire-dependent communities such as prairies, southern sedge meadows, oak and pine savannas, and oak and pine woodlands (Curtis 1959, Swain 1978, Winkler 1985 and 1986).

Prior to European settlement, fire in North America was caused by both lightning and Native Americans. Fire was probably a major influence on the landscape long before human arrival. Fossil records suggest that fire began to play an important role in central and eastern North America around 25 to 30 million years ago. At that time, the climate apparently became drier, and plant species that depend upon (or at least tolerate) a combination of grazing, drought, and fire, such as oak and grass species, experienced prolific species radiation as savannas and grasslands began to dominate large regions (Barry and Spicer 1987[2]).

Indigenous peoples most likely increased fire's influence on the landscape, at least in the Northeast, where lightning-induced fire was less common than in the West or in the Southeast (Komarek 1964, 1967, 1968, and 1974, Barden and Woods 1974, Higgins 1984, U. S. Forest Service 1987). Although direct proof of intentional burning of the landscape by early peoples is unattainable by nature, archaeological evidence and ecological evidence suggest that Native Americans actively managed the land with fire for hundreds, if not thousands, of years (Grimm 1984, Patterson and Sassaman 1988, Dorney and Dorney 1989, Denevan 1992). Native Americans likely used fire to enhance production of game, roots, nuts, and berries, and to make their own movement across land easier (Lewis 1980, Pyne 1983). Today fire, in the form of prescribed burns, is used frequently as a management tool. This is not only because of its historical role in maintaining and influencing native ecosystems, but also its low cost relative to other habitat management tools.

In Wisconsin, an estimated 12 to 22 thousand acres are purposefully burned under prescription annually. These burns are conducted by a wide variety of agencies and groups, including the Wisconsin Department of Natural Resources (70%); private conservation groups and individuals (15%); federal agencies—U.S. Fish and Wildlife Service, U.S. Forest Service, and National Park Service—(10%); county and municipal parks (3%); and the University of Wisconsin System (2%) (Henderson, unpublished data). The amount of prescribed burning done today is small compared with the hundreds of thousands, if not millions, of acres that probably burned on average each year in the state prior to European contact.

The primary purposes of today's prescribed burns are to (1) maintain (or create) wildlife habitat for game and non-game animals, such as grassland songbirds, prairie grouse, ducks, ring-necked pheasant, wild turkey, ornate box turtle, glass lizard, etc., and (2) maintain (or restore) native plant communities such as prairies, sedge meadows, oak and pine savannas (barrens), and oak woodlands. To a far lesser degree, burns are also conducted to prepare planting sites and to reduce fire hazard.

Fire is a flexible management tool that permits the outcome of a burn regime to be manipulated to fit the ecosystem, species, and management goals at hand. Burn regimes have 3 main variables that determine effects on resources: seasonal timing, frequency, and intensity of the fire(s). These variables are within the control of managers. Therefore, it is very important that managers have knowledge and information about how these variables relate to fire effects. This knowledge enables them to prescribe effective burn regimes to achieve the desired results without incurring negative side effects (such as unintentional loss of species or escaped fire). Unfortunately, our knowledge of fire effects as they relate to the variables of seasonal timing, burn frequency, and fire intensity is far from complete, and the information that is available is often buried in the literature, inaccessible to the average land manager.

We hope this publication will provide a step toward bridging this gap between information and managers. Our intent is to make it easier for land managers to access information on specific fire effects that are applicable to the species and ecosystems of Wisconsin.

We are publishing this bibliography and its indexes now to avoid further delay in making the information accessible. However, we hope to eventually produce a more refined and complete bibliographic index that will be electronically accessible and searchable by managers and researchers statewide.

[1] Literature references in the Introduction are found in the list of literature citations, unless otherwise noted.
[2] Barry, A. T. and R. A. Spicer 1987. The evolution and paleobiology of land plants. Croom Helm, London. 309 pp.

How to Use This Bibliography

This bibliography has 841 references and is organized into 3 companion indices: one of general topics, one of species, and one of geographic location by state or province of fire effects information or research. The articles and publications in the bibliography are arranged in alphabetical order by author and are numbered sequentially. These numbers are used in the indexes to match references with subject categories. (**Note**: Cross-reference indexing is not complete. Often only the primary subjects of a reference are adequately indexed. For example, all references with information about species X's response to fire are not necessarily listed under species X, but all references with species X as a major subject of the study are listed under that species.)

Methods of Compilation

This bibliography was built from a card file begun by the senior author in 1978. Beginning in 1985, this file was kept updated with regular use of both *Current Contents* and *Wildlife Review*.[3] The subject categories of fire(s), wildfire(s), and burn(s)(ing) were routinely reviewed. In 1990, updating from *Current Contents* became electronic when it became available on disk. This made it possible to review not only keywords, but also titles and abstracts.

In 1989, the file was augmented with citations from a literature collection on fire effects compiled by the Department of Natural Resources' Prescribed Burn and Fire Effects Committee. In 1992, the file was augmented further with the published proceedings from (1) a 1986 symposium, "Prescribed Fire in the Midwest", held at University of Wisconsin-Stevens Point; (2) all biennial North American Prairie Conferences, 1968-90 and (3) all Tall Timbers Fire Ecology Conferences, 1962-89. Chapters or articles from major literature review books on fire effects, such as Kozlowski and Ahlgren (1974), Wali (1975), Wright and Bailey (1982), Chandler et al. (1983), and Collins and Wallace (1990) were also included.

Subject indexing was accomplished by first establishing an outline of categories and cascading subcategories. Standard terms were then adopted as headings for each category and used as the keywords. All articles were then lightly reviewed for subject content and all applicable keywords were assigned. A few reviews were limited to abstracts only. The subject (keyword) outline was refined as the indexing proceeded. Pro-Cite was the software used for managing the citations and their keywords.

Overview of Fire Effects in Wisconsin

Although information on fire effects in the Midwest is far from complete, enough is known to draw some general conclusions and to predict, with moderate accuracy, the impacts of a given burn. What we do know is that ecological responses to fire can vary greatly due to the influence of many variables, such as vegetation type, specific plant and animal adaptations, fire history, soils, climate, and current fire regime.

Of all these variables, fire regime is the only one over which managers have much control, but it is also one of the more important in determining long-term outcomes. Fire regimes have 4 primary variables; (1) seasonal timing, (2) frequency, (3) heat intensity, and (4) heat duration. The last 2, heat intensity and heat duration, are often lumped together into one variable that is often referred to as intensity. Selecting target values for these variables in burn-planning are some of the most important decisions a manager makes in prescribing fire, the most important being whether or not to burn the site at all.

Species responses to fire are **never entirely positive nor entirely negative**; there are always some species harmed, some benefitted, and some unaffected by any given fire. In very general terms, ecosystems, communities, or species historically dependent upon fire for their existence or dominance benefit from prescribed burns under the right conditions. In Wisconsin these communities include prairie, sedge meadow, oak savanna, pine barren, pine forest, and most oak forest types. These communities are not all equally dependent upon fire, however. Frequent burning, for example, usually results in prairies and meadows, whereas the forests are sustained by less frequent, or at least less intense, fires. Conversely, ecosystems, communities, or species not historically dependent upon fire do not generally benefit from fire. In fact, fire may damage or alter them so severely that recovery may take centuries. In Wisconsin these communities include the various mesic and wet forest types, and most sphagnum bog types.

Any evaluation of burn regimes should take into account effects of other factors, such as climate, herbivory, and their interactions with each other and fire. Unfortunately, species adaptations to fire can not be easily separated from adaptations to grazing or drought stress; therefore it is often difficult to distinguish among the influences these forces have on vegetation. To complicate the situation

[3] *Current Contents: Agriculture, Biology & Environmental Sciences*, published by the Institute for Scientific Information, and *Wildlife Review*, published by the National Biological Survey, are both available electronically at most academic libraries and at the DNR Research Library.

further, these forces are not necessarily independent of each other. Fire is often associated with periodic drought, and there is sometimes an interaction between fire and grazing by large herbivores. For example, recently burned grasslands often attract grazers, and recently grazed areas usually resist fire until dead litter re-accumulates (Steuter 1988, Vinton et al. 1993). This means that any discussion of fire effects, at least from a historical perspective, must incorporate the potential influences of grazing and drought as well. Unfortunately, research that synthesizes this type of information is rare.

Although there is no doubt that grazing and browsing have historically played some role in affecting vegetation structure, it is unlikely, that herbivory played the dominant role in determining vegetation structure here in Wisconsin. There is compelling evidence that fire, facilitated by climate, was the overriding force on the landscape in southern and western Wisconsin and much of the upper Midwest. The juxtaposition of various native plant communities on the landscape, ranging from fire-dependent to fire-intolerant communities, in relation to natural fire breaks and prevailing winds during fire-prone conditions amply demonstrates this point. In addition, the body of evidence from sediment cores, tree fire-scars, and historical accounts (see citations under Fire History in the index) builds a compelling argument for fire's dominant influence.

The following generalizations of species and ecosystem responses to fire in Wisconsin represent the senior author's perceptions, derived from a synthesis of the literature and 18 years of field experience with fire and fire effects. They are intended only as an introduction to the topic, not as citable conclusions of any particular research. **These summaries apply only to fire-dependent or fire-tolerant ecosystems of Wisconsin** and are sometimes handicapped by a scarcity of published data. Also, keep in mind that there are often exceptions to the rules, and the responses referred to are


R. HENDERSON

The left half of this photo shows the litter removal, shrub kill-back, and advanced green-up in a sedge meadow resulting from an early spring burn. Right half is unburned.


R. HENDERSON

A sedge meadow in June showing the kill-back of shrubs caused by a fire 2 months earlier.


J. HEISE

A low-intensity back-fire in oak savanna ground litter.

not always expressed in the first post-fire season. In fact, many responses, such as tree mortality, changes in soil fertility, population changes of long-lived species, and some flower or seed production, may not be expressed until several years after a burn, or they may require repeated burns for many years before they become evident.

A. Fire Effects on Vegetation:

1. Increase in species diversity, both richness and equity of species representation. (However, fire intolerant species, such as some woodland spring ephemerals, may be lost; vulnerability varies with the timing of the burn.)
2. Short-term increase in annual and biennial species (e.g., ragweed [*Ambrosia artemisiifolia* and *A. trifida*] and sweet clover [*Melilotus alba* and *M. officinalis*]), but normally not at the long-term expense of perennials. (However, fires at certain times of the year can actually reduce or eliminate annuals and biennials.)
3. Long-term shift in dominance away from plants with most of their biomass above ground to plants with most of their biomass below ground.
4. Increase in flower, seed, fruit, or nut production (as much as 10 fold in some exceptional cases).
5. Increase in biomass (forage) production both above and below ground for one or more years. (This is especially true in native prairie.)
6. Improved forage quality, both in nutrition and palatability.


R. HENDERSON

An increase in flowering resulting from fire in prairie.

B. Fire Effects on Animals:

1. Initial drop in numbers and species. (This results from some mortality among invertebrates, reptiles, and small mammals—but rarely birds and large mammals—and some emigration of litter-dependent birds and mammals. A notable exception to this initial-reduction rule of thumb is the immediate increase in the use of burned areas by many foraging and hunting species—especially birds—drawn by more favorable foraging conditions.)
2. Eventual increase in animal numbers and species that meets or exceeds pre-burn levels. (This increase may occur within months or it may take several years. It is generally the result of increased primary and secondary productivity and the consequential ripple effect up through the food chain, improved habitat structure, or both.)
3. Should a species be totally removed or driven out from a given site by the effects of a fire, it will recover on that site only if individuals from another site are close enough to recolonize. Dispersal distance varies by species. The effective dispersal distance of some insects ranges from less than 100 feet to several miles. Birds, on the other hand, recolonize readily over distances of dozens to hundreds of miles. (Unfortunately, it is not well documented which species fall into this "need to recolonize" category. Some habitat-specialist insects—such as those restricted to prairie or other remnants of native vegetation—may be among them. If so, potential presence of these species requires caution when using fire, such as leaving viable "refuge" areas unburned.)

C. Fire Effects on Soil:

1. Reduction of litter, duff, and humus layers above the mineral soil surface resulting in warmer soil temperatures.
2. Increase in fertility and organic matter within the mineral soil resulting from increased plant root and soil micro-organism activity. (This can result in significant permanent carbon storage that may be capable of reducing atmospheric CO_2 levels in the long run.)

M. SKINNER

A prescribed burn of an oak savanna at dusk.

GENERAL SUBJECT INDEX *(continued)*

FIRE HISTORY

FIRE POLICY

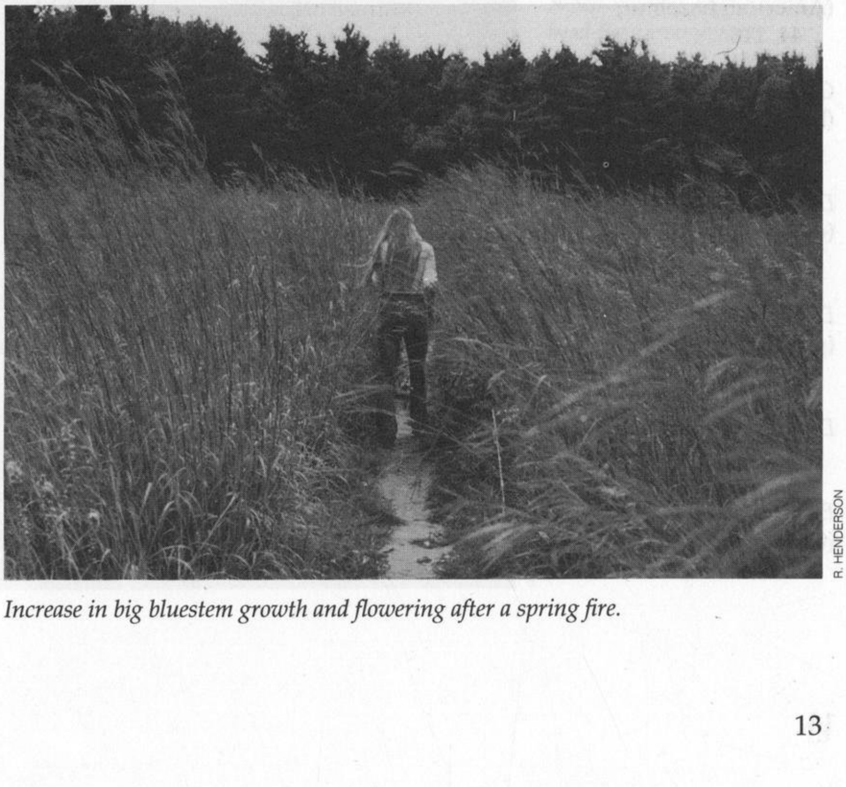
FIRE REGIMES (effects of)

OTHER MANAGEMENT RELATED TO FIRE

PRESCRIBED BURNING

PLANTS

The suppression of the non-native grass smooth brome invading dry prairie. The left half was burned in May. The right was unburned. (photo taken in August)



Increase in big bluestem growth and flowering after a spring fire.

R. HENDERSON

A fast-moving, high-intensity head-fire through reed canary-grass.

INVERTEBRATES

REPTILES AND AMPHIBIANS

BIRDS

SMALL MAMMALS

LARGE MAMMALS

GEOGRAPHIC INDEX
(U. S. States and Canadian Provinces)

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About the Authors

Richard A. Henderson has been a researcher with the Wisconsin DNR Wildlife and Forestry Research Group since 1984 and is currently the Terrestrial Ecologist stationed at the DNR Research Center, 1350 Femrite Drive, Monona, Wisconsin 53716. Rich has maintained an active interest in fire ecology since completion of his M.S. thesis on the effect of seasonal timing of fire on native prairie vegetation which was completed at the University of Wisconsin-Madison in 1981.

Sandra H. Statz is currently a graduate student of Entomology at the University of Wisconsin-Madison, where she is specializing in the taxonomy and systematics of Coleopterous insects. Sandi also maintains a general interest in the ecology and management of Wisconsin's diverse habitats.

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