Controlled Burning for Wildlife in Wisconsin

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THE PURPOSE of this paper is to discuss and evaluate the effects of fire on wildlife and its uses in Wisconsin game management. This treatise will deal exclusively with fire and will perhaps unduly emphasize it to counteract its neglect and misrepresentation. However, as an ecologist, I am obliged to point out that fire is only one of many environmental factors to be considered in land management, and any true ecological assessment must consider all factors in harmonic unison.

The use of prescribed fire in Wisconsin is not considered an introduction to a new management tool, but is rather the return of a natural ecological factor to the environment. Wisconsin ecologists have long recognized fire as a factor that helped shape the vegetation encountered by the first explorers (Curtis, 1956). The so-called pristine forests, prairies, and savannas of Wisconsin evolved and developed under the presence of fire (Curtis, 1959).

The arrival of European man, however, started the abolishment of fire either indirectly by agriculture destroying the fire-carrying fuels and creating firebreaks (Curtis, 1959), or directly by establishing fire protection (Mitchell and Le May, 1952).

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My first introduction to fire as a great natural force came when, while waiting out a thunder squall on the Apostle Islands in 1956, Professor Grant Cottam told of his research in southwestern Wisconsin (Cottam, 1949). He related that most trees in southern Wisconsin were less than 100 years old and dated back to a general cessation of fires. My first reaction was one of amazement and disbelief because this was contrary to a myth developed during my boyhood. As a youth, I spent my summers hiking southern Wisconsin woods, and I often imagined that Indians once walked, hunted, or camped under the same trees.

The changes wrought by the general cessation of fires were dramatic in the prairie portions of the Lake States. Often, while attempting to teach the principles of plant succession to ecology students in the West, I find inconsistencies between certain aspects of succession and what I find on the western landscape. Perhaps some of these inconsistencies occur because the succession concepts were founded and developed under atypical conditions in the Midwest. The conditions were atypical because succession was developed in a region undergoing a dynamic land change as young forests were unleashed from their flaming bonds. Trying to fit the more stable forests of the West to concepts developed in vegetation types undergoing rapid changes, is, perhaps, like trying to describe the natural vegetation of New Zealand by studying vegetation that has been disturbed and destroyed because of the introduction of deer.

The role of fire in postsettlement vegetational changes is summed up by Curtis (1959):

> In the early years of settlement, the most important vegetational effects were caused by the elimination of fire, the major Indian agent of control.

Curtis continued:

> The best evidence for this is seen in the savanna and prairie region, where lands spoken of as brush and treeless by the earliest explorers became covered with brush or young forests when the major settlements were made after 1830.

Evidence of woods springing up and forests filling in can be found throughout Wisconsin. While conducting fire research in Wisconsin,

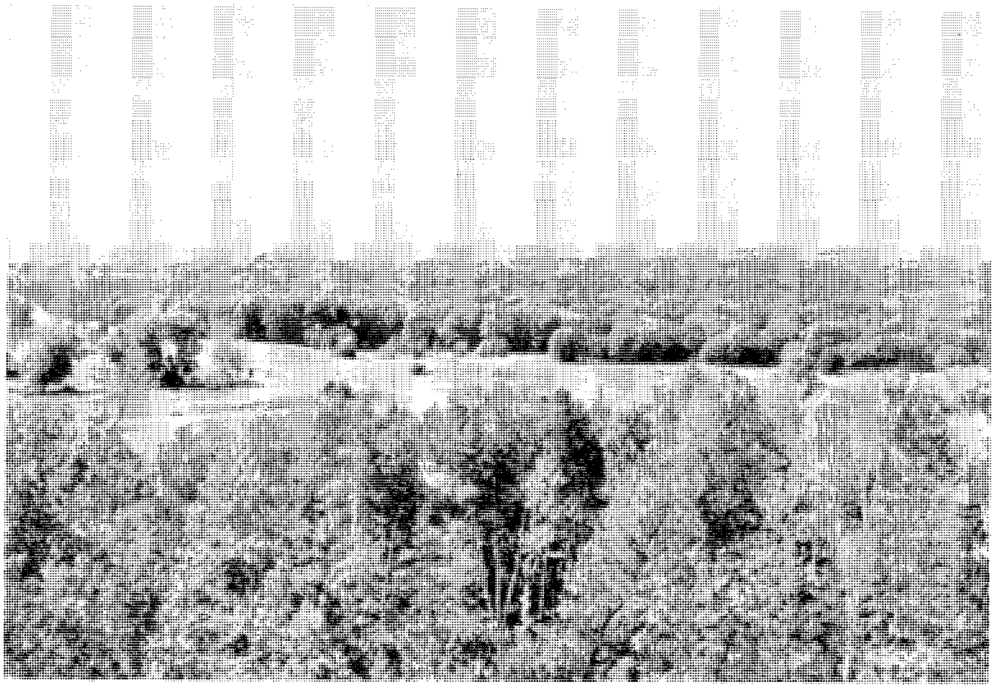


FIG. 1. View from Grantsburg fire lookout in northwestern Wisconsin. Region was once occupied by open brush prairie savanna and is presently covered with dog-haired thickets of worthless woody plants.

I climbed each fire tower encountered to learn of local fires to sample and to get an aerial view of the vegetation. Whenever I met an old timer "riding the tower," I got the same story; a story of their witnessing the growth of the surrounding countryside and the disappearance of wildlife. For example, the view from the Grantsburg fire tower (Fig. 1) shows a scrub oak forest (*Quercus ellipsoidalis*) that was once an open brush prairie savanna (Vogl, 1964c). C. Nordstrom, a resident of the area, commented that the country between his father's homestead and Grantsburg, about eight miles away, had been open so that one could see the town of Grantsburg on the rise to the south in the early 1900's (Fig. 1). He told how difficult it had been to find timber for fence posts on the farms in the region and how repeated fires had kept the area open (Vogl, 1964c).

George Chido, Spooner forest protection officer, stated that most of northwestern Wisconsin consisted of worthless burned-over country at the onset of forest protection in the late 1920's. The area still consists of worthless "popple" (*Populus* spp.), jack pine (*Pinus banksiana*), and scrub oak.

Upland areas were not the only regions to undergo dynamic land changes. There are approximately 2,790,000 acres of wetlands in Wisconsin which are threatened by plant succession, among other things, as open marshes are converted from aquatic to terrestrial sites. Jahn and Hunt (1964) summarized much of the problem by stating:

> Historically, fire maintained attractive duck breeding habitat by inhibiting normal plant succession. Grassy and herbaceous upland cover established and maintained by fires provided excellent nesting cover for upland nesting ducks, such as the blue-winged teal and mallard. Under present-day, strict fire protection, new depressions are rarely burned in meadows, and sedges and grasses give way to shrubs and trees. Timbered swamps stand as living testimonials of what vegetation more open wetlands will support at some future date, if they remain undisturbed.

In a few remaining places, particularly in xeric plant communities or in those with a rapid build-up of flammable fuels, fire protection has not greatly affected the occurrence of fires (Lake States Forest Experiment Station, 1939). The worst fire in the history of Wisconsin's forest protection was the Webster-Grantsburg fire that consumed over 20,000 acres in May, 1959, demonstrating that large fires can still occur in fire country.

Not all forest growth and encroachment in Wisconsin is a result of fire protection. Reforestation programs, started throughout the state with the establishment of county forest plantations, played an important role (Wisconsin Conservation Department, 1938). Current and projected forest plantings (Beale and Dieterich, 1963) coincide with the remaining openings in Wisconsin which represent the last strongholds occupied by open-country game. Unfortunately, the growing of trees and forests, no matter of what kind or quality, is still associated in the minds of some conservationists with the growing of wildlife (Harrison, 1967). This self-righteous attitude towards planting pine trees may be a decisive factor in completely eliminating openland wildlife from Wisconsin. Such "conservation" activities may ultimately lead to the filling in of the last open country or the the creation of high fire hazards adjacent to openings, thus rendering the use of fire in remaining clearings unsafe.

In summary, Wisconsin's landscape has moved from a rich mixture of prairies, barrens, clearings, savannas, and forests to an unproductive, monotonous, homogeneous and almost endless forest. This transition has produced a loss of valuable openlands for wildlife and a loss of game-producing edges. Much of Wisconsin has become a place where "you can't see the forest for the trees," and, consequently, a place where "you can't see (or find) the wildlife for the trees." Controlled burning has been initiated to check and push back the encroaching woody vegetation, to recreate openings, and to produce vegetational conditions similar to those present in presettlement times.

> In the manifold field of conservation, the practical land manager is coming to realize that most of his activities are directed at the control and manipulation of plant communities, whether his apparent interests lie in forests, game, fish or soils (Curtis, 1959).

HISTORY OF CONTROLLED BURNING

A review of the establishment and development of the use of fire in Wisconsin will, perhaps, give perspective in evaluating its present use. The concept of controlled burning for Wisconsin wildlife is less than 40 years old. The use of fire in Wisconsin was undoubtedly sparked into life by Herbert L. Stoddard, Sr. Stoddard's influence was not direct, however. Although he was in and out of Wisconsin from about 1910 to 1930 working for the Milwaukee Public Museum, the old Field Museum of Natural History in Chicago, and the U. S. Biological Survey, he did not do any burning in the state, nor was he involved with Wisconsin Conservation Department (W.C.D.) administrative policies. During this time, he began to correspond with Wallace B. Grange and Aldo Leopold, and, through them, his ideas on fire permeated the state and W.C.D.

The correspondence of Grange and Stoddard was started by a mutual interest in birds which led to a lasting friendship. This friendship was reinforced by the strikingly similar backgrounds of the two men. Both individuals were born in "civilized" Illinois; Stoddard in 1889 and Grange in 1905. But, more importantly, both spent a part of their childhood moving with their pioneer families into the "wilds." Stoddard moved to Florida and Grange moved to northern Wisconsin. It was in these places that both youngsters obtained their basic love of the land and their first experiences with fire. Stoddard's exposure to fire came as he watched Florida cattlemen put fire to the piney woods (Stoddard, 1962c, 1963). Grange's experience was gained as he helped his parents burn to clear their land. Grange stated:

> I had no inkling at that time of the beneficial effects fire might have on wildlife; it was strictly a land-clearing undertaking. But it made a big impression on me, especially since it revealed a great many old beaver canals that had escaped my notice and which set me to wondering and thinking, about the changes that must have taken place (personal communication, 1967).

These first experiences with fire left a lasting impression with Stoddard and Grange concerning the usefulness of fire. This opportunity was denied those who followed; those who were born into a world prejudiced toward fire. Grange and Stoddard finally met in 1926 and began spending time in the field together where Stoddard shared his ideas on game management and fire. In 1928, Grange became the one-man W.C.D. Game Division and in the succeeding years made friends with Aldo Leopold.

Leopold graduated from Yale Forestry School and began working for the U. S. Forest Service in Arizona and New Mexico in 1909. In 1924 he came to Wisconsin as associate director of the U. S. Forest Products Laboratory in Madison. Leopold left the field of forestry in 1928 to initiate a series of wildlife surveys. In 1933 he became professor of game management at the University of Wisconsin and began training students in this new field.

While Leopold was in the Southwest, he became aware that fire played more than the traditional role of a destroyer. His ideas (Leopold, 1923, 1924) contained the rudiments of a basic ecological approach to fire. However, his thoughts on fire as a game management tool were superseded by, and, for the most part, founded in those of Stoddard. Dr. Robert A. McCabe, a student of Leopold, stated, "One of the very first seminars that I heard him [Leopold] give was on the use of fire in quail management, where he cited a number of experiments undertaken by Herbert Stoddard in Georgia" (personal communication, 1966). In 1931 Leopold threw his support behind Stoddard's work on game management and fire (Schiff, 1962). The extent to which Leopold supported and used Stoddard's ideas on fire is documented in Leopold's book (1933) on game management. Grange summarizes this by stating, "It is very possible that Herb [Stoddard] picked up a few ideas from Leopold, but I am positive that Leopold picked up a great many of them from Herb. At any rate, they held one another in high esteem" (personal communication, 1967). It appears that Leopold's main contribution to the use of fire was that he capitalized on his position as an administrator, educator, and prolific writer to promote, disseminate, and elaborate Stoddard's ideas and findings. McCabe (personal communication, 1966) stated, that "I can best sum up Aldo's relationship to fire ecology to say [sic] that he strongly supported the use of fire as an ecological tool for regulating game habitat."

Although Leopold eventually became an advocate of controlled burning, it was only with some difficulties that he succeeded in overcoming his previous forestry indoctrination. A note published by Leopold (1926) still carried the traditional all-out attack against fire. Leopold never was able to break the forestry tradition of "planting trees" as evidenced by his pine plantations in the University of Wisconsin Arboretum and on his Sauk County property. These same plantations later complicated burning of the adjacent Arboretum prairie and prevented the fire maintenance of Leopold's sand prairie openings (McCabe, personal communication, 1966).

Ironically, Aldo Leopold died on April 21, 1948, while fighting a grass fire. It was almost as if fire, which Leopold respected as only a forester can, and which he had learned to recognize as a great natural and ecological force, had come to claim a friend; one who had a closer kinship with nature than he did with the majority of his exploiting fellow *Homo sapiens.*

BURNING BEGINS

Wallace Grange conducted the first burn for game purposes in Wisconsin in 1939. The burn was carried out on a 100 acre tract of marshland and upland on his Sandhill Game Farm. Burning resulted in the early growth of grass, increased willow and aspen regeneration, diversified the vegetation, and exposed bare soil for pioneer game foods (Grange, personal communication, 1967). The burn was conducted by Grange and two employees for prairie chicken, sharptail, ruffed grouse, deer, and duck habitat. In 1939 Grange burned over 1,300 acres on 30 different sites and from then until 1962, he used fire at regular intervals, often burning alone, to produce high game densities on his farm.

Under the auspices of Grange, the first controlled burning for game by a public agency in Wisconsin was conducted on April 17, 1941 (Grange, 1948). The burn was part of the management plan for the W.C.D. Grouse Project. Grange summarized the importance of this first fire by stating:

> This burn was under quite wet conditions and was not particularly successful for that reason, but it was significant, none the less, for it represented a change in official Department policy, and was actively participated in by the personnel of the Babcock Ranger Station—formerly much opposed to the whole concept. Permission to do even this much, on publicly owned land, had required months of 'negotiation,' if that is the proper word to describe the squabbling, buck-passing and wrangling that preceded approval (personal communication, 1967).

The W.C.D. controlled burning program developed rapidly after this first burn. In 1946 W.C.D. burned 800 acres in central Wisconsin for deer and general game. J. Robert Smith burned 5,800 acres for waterfowl on state-owned Horicon Marsh (Grange, 1948). One of the burns in central Wisconsin by Fred Jacobsen, conservation warden, merited special recognition, because it was the first publicly sponsored burning by other than W.C.D. research staff (Grange, 1948).

In 1947, control burning was introduced to northwestern Wisconsin. As part of the Grouse Project, a burn was executed on the Douglas County Grouse Area in 1948 with the assistance of James B. Hale. Burt L. Dahlberg became northwest area supervisor.

Burt L. Dahlberg was reared in the same "wildwoods" as Wallace Grange. Interestingly, Dahlberg's father was a trained biologist and a highschool teacher of Grange, and young Dahlberg and Grange became life-long friends. As a youth Dahlberg witnessed the end of the logging and the fires that followed. As a result of this background, Dahlberg had a different perspective toward fire than most. He wrote (personal communication, 1967):

> Sharptails were abundant when I was a boy but it didn't take a good area very long to 'grow up' and instead of sharptails, ruffed grouse became our game. It didn't take much intelligence on my part to see that fire wasn't an end—but rather a new beginning.

Dahlberg became acquainted with Stoddard's work through Grange, and later through Leopold while Dahlberg was conducting research on deer (Dahlberg and Guettinger, 1956). Since then, Dahlberg has become one of the main contributors and promoters of the use of fire for game purposes in Wisconsin. Dahlberg permitted game manager Norman Stone to use fire on the newly established Crex Meadows Wildlife Area, a wetlands restoration project. Stone has been burning to provide maximum game production, to maintain and improve prairie grouse habitat, and to improve duck nesting habitat around the edges of the many sloughs and ponds since 1948 (Vogl, 1964c). As a result, Crex Meadows has become a showplace for fire and its uses, is the most intensively burned wildlife area in the state and is perhaps one of the most productive.

Grange's books on *Wisconsin Grouse Problems* in 1948 and *The Way to Game Abundance* in 1949 helped pave the way to an accelerated controlled burning program. Stoddard summed up the 1948 publication by stating, "For instance, where else has the profound effect of fire on the wildlife habitat of the region been discussed so ably?" (Grange, 1948). Controlled burning on sharp-tailed grouse areas became a commonplace management practice by the 1950's.

Another advancement in the program developed when W.C.D. obtained sharptail management units within the Nicolet National Forest. These areas were to be managed and burned by W.C.D. The use of fire on U. S. Forest Service lands was strengthened in 1964 when 3,000 acres were set up as a sharptail management area within the Chequamegon National Forest (Bublitz, 1964). With the efforts of Burt Dahlberg and Howard Sheldon of the U. S. Forest Service, the first burn of 170 acres occurred in 1964 (F. Stearns, personal communication, 1967). Since then, about 100 acres have been burned each year. Dahlberg (personal communication, 1966) stated:

> We finally broke the 'red tape' barrier on the Moquah Barrens—U.S.F.S. lands under management agreement three years ago and have used fire in our management there since that time. Sharptail response has been rewarding.

The northwest area deliberately burned 8,645 acres in 1964, 3,864 in 1965, and 6,254 acres in 1966. As a result of this large annual burning, both Norman Stone and Burt Dahlberg have become very proficient in the techniques of burning. The W.C.D. burning program has greatly expanded. The five management areas of the state participated, in 1965-66, in burning a total of 11,940 acres (Annual Game Management Report, 1966, unpublished). About 24,000 acres were controlled burned in 1964-65 (King, 1966) and approximately 19,000 acres were fired in 1963-64 (Hartman, 1965). In 1963, interestingly, twice as much land was burned on purpose as caught fire accidentally in Wisconsin (Milwaukee Journal, 1963). In that year, more than 13,000 acres were burned by Norm Stone on Crex Meadows Wildlife Area. Relatively large areas have also been burned in the Mead Wildlife Area in north-central Wisconsin where 37 burning operations involving some 12,520 acres have been carried out since 1960.

The late Professor John T. Curtis, plant ecologist at the University of Wisconsin, should also be recognized for his contribution in developing the use of prescribed fire in Wisconsin. Although he held the academic position of Professor of Botany, he was interested in the practical aspects of ecology and the application of ecological concepts by the land manager. Curtis' research definitely demonstrated that fire was an ecological factor that profoundly affected the original vegetation of Wisconsin (Curtis, 1956), and that fire was necessary for the maintenance of certain native plant communities (Curtis, 1959). His work and the work of his students (Curtis and Partch, 1948; Cottam, 1949; Curtis and Partch, 1950; Archbald, 1954; Dix and Butler, 1954; Robocker and Miller, 1955; Vogl, 1961, 1964a, 1964b, 1964c, 1965) demonstrated the beneficial and ecological effects of fire on native Wisconsin plants. This research helped to confirm the need for a burning program in the state and dispelled doubts about the worth of the program.

Part of Curtis' interest in fire originated in the writings of botanists Henry A. Gleason, then of Illinois, and Roland M. Harper of Alabama. He particularly admired the original contributions these men made to fire ecology. Gleason (1913, 1923) had observed that eastern and northeastern shores of bodies of water in central U. S. contained larger tracts of forest and more mesic vegetation than the corresponding west and southwest shores. Gleason explained that, although large prairie fires swept across the country from the southwest to the northeast, the bodies of water provided natural fire breaks which prevented destruction of the forests on the eastern shores. Curtis felt that Gleason's observations had wide application and could be considered a principle of fire ecology. Interestingly, Harper (1911) developed the same concept for Florida's swamp country. Harper's contributions to the field of fire ecology are numerous (Harper, 1912, 1913a, 1913b, 1913c, 1914, 1916, 1940). Of these, Curtis was most impressed by a statement made by Harper (1913b) concerning lightning in the long-leaf pine country.

> Of course this would not happen [lightning-started fires] very often on any one square mile, perhaps not more than one in one hundred years,—when there were no roads or fields to stop it, a fire started by either cause might spread over 100 square miles, and if that were the case the average frequency of fire on any one square mile would be about once a year.

Curtis felt this logical and reasonable statement could not be refuted and, therefore, dismissed the arguments of those historians and anti-fire propagandists who claimed that fire was only of minor importance before the arrival of man in North America.

Arboretum Burning

A prairie was re-established on the University of Wisconsin Arboretum between 1935 and 1941 (Cottam and Wilson, 1966). Around 1940, it had become apparent that the prairie would need to be managed to be maintained. Professor Leopold and two students, John A. Catenhusen and Robert A. McCabe, carried out experimental burns. Curtis and Partch (1948, 1950) studied the effects of these

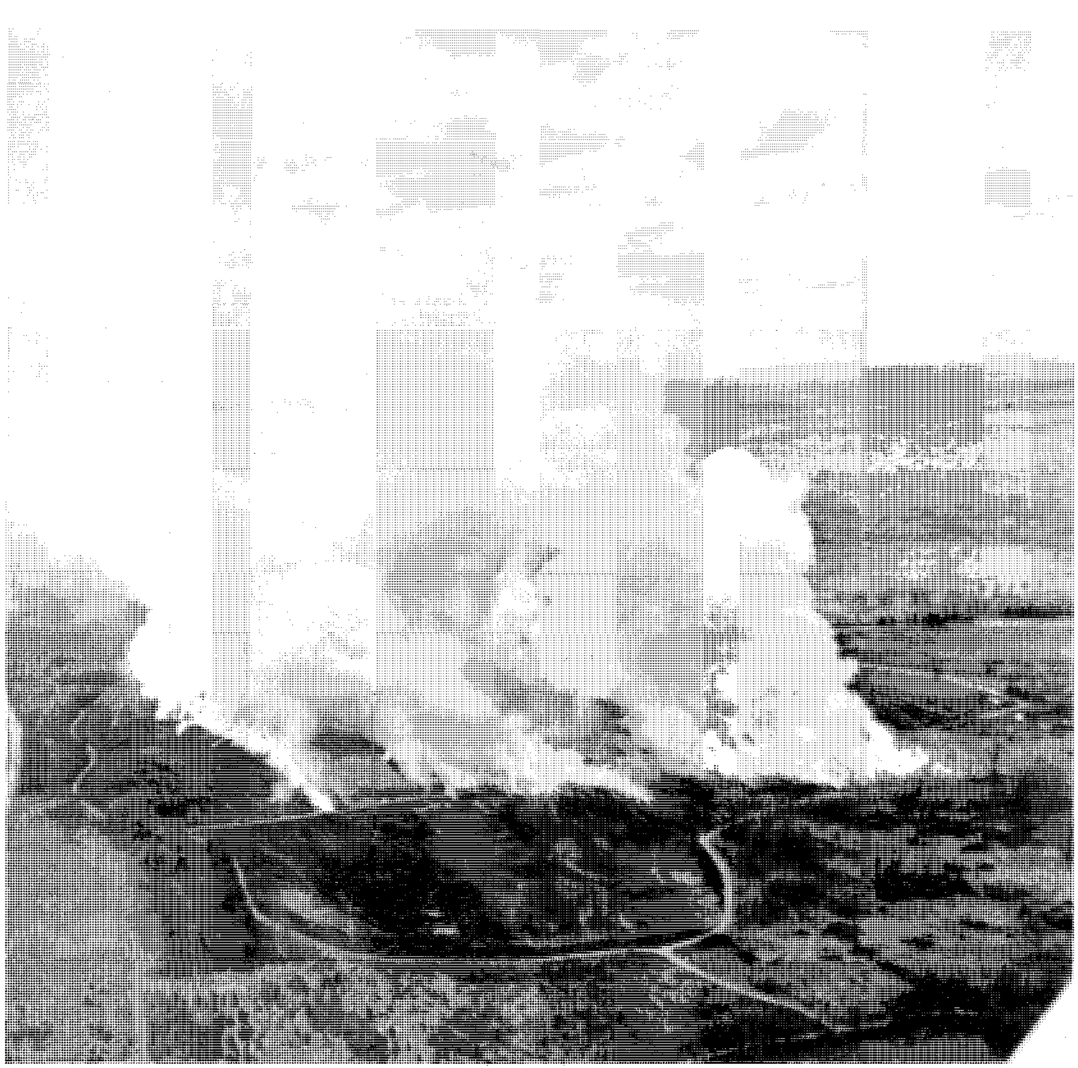


Fig. 2. The biennial burning of the University of Wisconsin Arboretum prairies. Controlled burning maintains the prairie vegetation and eliminates encroaching woody and undesirable plants. Photo courtesy of Univ. Wisconsin Arboretum and Extension Div., Dept. of Photography.

burns and pointed out their beneficial qualities. Based on these results, the first controlled burn was conducted in April, 1950, in the University of Wisconsin Arboretum (Nielsen, 1963), and Curtis ultimately wrote a master plan that placed the prairie (Fig. 2) on a two-year burning cycle (Cottam and Wilson, 1966).

There was no opposition to, nor criticism of, the burning by the Arboretum Committee. Cottam (personal communication, 1966) suspected this was because the ground work was so well founded in the Curtis and Partch (1948, 1950) research. The burning of the prairie convinced the local public as well as some of the top W.C.D. administrators in Madison that fire could be a useful tool.

Sachse (1965) summarized the Arboretum fires as follows:

> Of all the Arboretum specialists, none knew better than Curtis how to turn the element of fire to good use, especially in the development of the prairie. . . . . . . the first controlled prairie burning was carried out scientifically in the Arboretum, and from then on became a biennial practice. Fire kept down the constantly invading woody plants and such undesirable plant associations as blue grass, white sweet clover, wild parsnip, and Canada thistle. It also removed the thick layer of accumulated mulch, leaving the prairie plants free to flower and reproduce.

The biennial burning of the Arboretum prairie was called to the attention of the public when Walt Disney requested that his cameramen be allowed to photograph the 1953 prairie burning as part of a wildlife documentary, *The Vanishing Prairie*, for, he felt that there was no other place in the world where such an event could be recorded (Sachse, 1965).

Scientific Area Burning

In 1951, a State Board for the Preservation of Scientific Areas was established in Wisconsin by legislative action (Curtis, 1959). Curtis was one of the founding fathers who promoted the use of fire to maintain certain plant communities in the successional stages for which they were originally preserved. For example, under this legislation, a 79 acre plot on Crex Meadows was to be kept permanently as brush prairie savanna for scientific study. To do this, it was necessary to include fire in the management, or it would soon revert to forest (Vogl, 1964c). Other scientific areas that have burning in their management plans include Faville Prairie, jack pine—scrub oak areas in Governor Dewey Park and in Neceedah Wildlife Refuge, and Scuppernong Prairie (Cottam, personal communication, 1966). Until recently, the periodic use of fire was the only major management tool used to control invading shrubs and trees in grassland preserves (Bray, 1957). Now, however, light logging is planned in combination with the usual fire treatment in areas where the forest has made serious encroachments (Loucks, 1966, unpublished).

RETROSPECT

In examining this brief interval of Wisconsin history, it is obvious that the present use of fire for game purposes can be traced to a small nucleus of men. The idea was born among Florida cattlemen, formulated in the mind of Stoddard, and spread to Wisconsin by way of Grange and Leopold. These ideas are still being used and advanced by a small dedicated group of land managers, with Dahlberg as one of the primary leaders. The research and ideas of Curtis, his use of fire in the Arboretum and other scientific areas gave solid reinforcement to the program.

I have attempted to present the history of the circumstances which produced the thought behind this fire movement. The immediate environment, the period in which they lived, local background, personal experiences, and the individuals whom they met were all important factors in conditioning the minds of these founders to be receptive to certain ideas which influenced their thinking.

It is an unfortunate truth that frequently history is written after those who have played an intricate part in its making are deceased. Attitudes are interpolated from hearsay, biography, or assumption. I believe that the sequence of thought behind this presentation is quite accurate, since those men who pioneered the field were personally contacted and provided this information which otherwise might have been taken to the grave, as so often happens.

Often, those individuals who are prolific writers are recorded as having been the initiators of history-making events, whereas the men who quietly did the work and formed the ideas are never given proper recognition. It is hoped that this account will clarify the record and be a means of giving credit to those to whom it is due.

EVALUATION PROBLEMS

One of the biggest drawbacks in evaluating the effects of fire on wildlife and wildlife habitat is the paucity of quantitative scientific data. This problem is not inherent to Wisconsin, but is a general problem wherever fire is encountered. In these days of "scientifically" developed and tested soaps, toothpastes, and deodorants, the empirical knowledge of the experienced game manager is becoming unacceptable. This is particularly true when it comes time to convince the scientific community, and to "sell" the current administration and public on certain burning practices. Empirical knowledge also tends to be restricted locally and usually dies with the individual.

However, knowledge gained empirically becomes invaluable when it is set forth as scientific hypothesis and run through the machinery of the scientific method. Research which starts with a strong and valid hypothesis often produces more meaningful results and conclusions, particularly in the broad realm of ecology.

Even when fire research has been validated by the scientific method, it has been my experience that most laymen and even some scientists, including biologists, find it hard to accept because it is contrary to their basic beliefs. These beliefs were indelibly inscribed in childhood by the reading of bedtime stores like *Smokey the Bear*, and by seeing movies like *Bambi*. The basic doctrine is established that fire is "bad" and is reinforced throughout life by a blitz of anti-fire propaganda (Schiff, 1962). Indeed, the process of openly accepting facts about the beneficial aspects of fire is analogous to convincing one to condemn motherhood or to convincing a starving Chinese faced with famine that if he just thinks positively, his hunger pains will subside.

I have found that many of my colleagues, including a few ecologists, find the concepts of fire ecology difficult to accept, and usually pass the whole thing off as amusing, perhaps interesting, but useless information. I might add that they only tolerate me on the basis that I am a cross between an eccentric and a pyromaniac. Even students, who are often passive and quite gullible, are immediately stirred into uneasiness when they realize the things I say about fire are in earnest. In summary, more fire research is needed, not only new or original studies, but also repetitious studies that will fortify established results so that even the most prejudiced layman has no choice but to accept the facts.

EFFECTS OF FIRE ON WILDLIFE

Burning has been conducted primarily for openland species such as sharp-tailed grouse, prairie chickens, geese, and upland species of waterfowl. Recently some burns have been executed to benefit white-tailed deer and ruffed grouse. In the process of burning for these species, pheasants, bobwhite quail, turkey, woodcock, Wilson's snipe, muskrats, and rabbits have benefited. In addition, non-game species, including some with high aesthetic value, have been increased by burning. Among these are such species as sandhill cranes, shorebirds, prairie and western songbirds, rodents, birds of prey, and predators, including the famous Wisconsin Badger. The Wisconsin Audubon Summer Camp features regular trips to Crex Meadows because of the variety of birds found only there due to the concentrated burning program.

A few of the more important game species will be discussed in the following sections.

Prairie Grouse

Both sharp-tailed grouse and prairie chickens and their habitat have gradually been fading from the Wisconsin landscape (Grange, 1948; Hamerstrom *et al.*, 1952; Lintereur, 1959; Hamerstrom and Hamerstrom, 1966). Typical sharptail country (Fig. 3) consisted of large open areas several thousand acres in size with scattered patches of low brush and thickets of young forest (Schorger, 1944; Newman, 1959). Prairie chicken requirements revolve around space and grass (Hamerstrom and Hamerstrom, 1966). In an effort to restore sharptails and prairie chickens to higher densities, intensive vegetational management was undertaken by W.C.D. Game Management. Twenty wildlife areas in the state, totaling 116,406 acres, were being managed for sharptails as of 1959 (Newman, 1959). Openings everywhere are reverting to forest as a result of improved fire protection and the abandonment of marginal farms followed by afforestation, as well as by reforestation. In some of these areas, prescribed burning is being used as a management tool to recreate openings in the encroaching forest (Schorger, 1962).

FIG. 3. Douglas County pine barrens provide favorable sharp-tailed grouse habitat. Open landscapes supporting scattered red pines (*Pinus resinosa*) and clones of jack pine (*Pinus banksiana*) have almost vanished in Wisconsin because of fire protection and afforestation.

Responses to prairie grouse management, including fire, have varied. In some areas, increases in habitat and populations have been encouraging (Hamerstrom and Hamerstrom, 1966; B. Dahlberg, personal communication, 1966). In others, populations have continued to decline (L. Lintereur, personal communication, 1966).

To my knowledge, there are no specific Wisconsin studies that experimentally evaluate prairie grouse response to fire. However, records of populations in the form of flushing and brood counts have been kept (Hamerstrom, 1963). Population fluctuations usually cannot be conclusively linked to fire because these grouse units have been affected by multiple treatments. For example, Hamerstrom (1963) did a sharptail brood habitat study on an area that had been treated with fire since 1948. He found that 80% of the sharptail brood observations were in open cover, 14% in edge types, and only 5% were more than 50 yards into the woods. The burning, however, as well as the experimental design, was set up so that the effects of fire could not be directly assessed. Results would have been complicated, also, by tree and brush cutting, spraying, and bulldozing done in the area. These different treatments were undoubtedly necessary in the "last ditch stand" to save these vanishing birds. Nevertheless, the multiple practices tend to mask the effects of any one management practice by blending the effects of all together. As a result, there is often inconclusive evidence as to the usefulness of any one tool, and if a manager has had a disappointing experience with any tool, he immediately abandons it to pick up another. With Wisconsin's diminishing populations of prairie grouse there is little room for errors in these "trial and error" methods. Since time is running out for the prairie grouse, basic research running concurrently with management is particularly essential to evaluate the management practices.

Fire has been used in the central Wisconsin sand plains, the last stronghold of prairie chickens (Hamerstrom and Hamerstrom, 1966) since about 1958. However, much of the region was used to grow bluegrass for seed in the past, and because of this and the extensive peat substrate, burning has been kept to a minimum (Hamerstrom *et al.*, 1957). Yeatter (1963) appeared to agree that burning should be kept to a minimum. He states:

> Although fire is frequently employed in the management of prairie plantings, it seems probable that on nesting refuges for prairie chickens it should be used infrequently and with considerable discretion.

In addition to the above reasons for curtailing burning, some distressing experiences have occurred as a result of fire (J. Hale, personal communication, 1962). For example, a fire by a local resident destroyed 840 acres of nest and brood cover. Another fire converted 200 acres of bluegrass to goldenrod. Despite these short-comings, fire still can be used to advantage in prairie chicken management, particularly when in experienced hands. Brush and tree invasion is occurring (Hale, 1962) and fire can reduce trees and other woody vegetation.

J. Berkhahn (personal communication, 1967) cited an interesting observation on a marsh burn:

> The most noticeable direct response I have ever witnessed to a burn was in April 1961 when a very well established prairie chicken booming ground moved over night to a new location on a marsh we burned the day before about ¾ of a mile away. This

> ground remained at this new location for two years until it disappeared when the area once again became heavily invaded by willow.

B. Dahlberg (personal communication, 1967) working in northwestern Wisconsin stated:

> Wildlife surveys specific to burning programs have been less than adequate except for sharptail grouse. We know beyond a doubt that given the land necessary for sharptails and the opportunity for management we can produce birds. A 34 year record of flushes during running of the National Chicken Championships by Northern States Amateur Field Trial Assn. on the Douglas County Wildlife Area offers good evidence of the response of sharptails to management (mostly burning).

The situation in north-central and northeastern Wisconsin is not as encouraging. Some of the management units have lost their sharptail populations and are being phased out. Some of the isolated openings created by W.C.D. have been about as effective in maintaining sharptails in this sea of trees as is a drop in the ocean.

Waterfowl

A major part of Wisconsin's burning program is devoted to the improvement of waterfowl habitat. A variety of objectives can be obtained using fire. In marshes with peat substrates, depressions are created by deep-peat burns in dry years (Grange, 1948). These depressions afford open water when flooded. Fire is used to clear flowage basins before diking and flooding. The ash promotes growth of desirable aquatic plants. Fire is often used in connection with the drawdown of water levels to create pioneer sites for the establishment of waterfowl foods. Excessive accumulations of fast-growing hydrophytes are removed, permitting better waterfowl access and a more palatable regrowth. Burning of sedge meadows and wet marshy areas provides excellent grazing for geese, waterfowl, deer, and non-game species like sandhill cranes. Fire is also used to retard hydrarch succession and the advance of woody vegetation. Lastly, fire is used to convert forested uplands adjacent to aquatic habitats to grasses and sedges, thus increasing the nesting potential of some waterfowl species.

Most of the successful burning has been done in connection with the development of flowages. Jahn and Hunt (1964) stated:

> When impoundments have been constructed and adjacent grassy and herbaceous nesting cover provided through prescribed burning, upland nesting ducks have responded quickly to favorable environmental conditions.

The least amount of burning has been done to natural marshes that have succeeded to shrub marshes or lowland forests. As a result, many productive marshes are presently occupied by impenetrable shrubs or by forests of water-pumping trees. There are approximately 2.5 million acres remaining of the original 5 million acres of Wisconsin wetlands (Anonymous, 1964). Areas that produced thousands of ducks in 1928-29, for example, are now heavily forested and have few ducks (Jahn and Hunt, 1964). Some of these areas are beyond restoration, but many could be brought back to waterfowl productivity by immediate management.

White-tailed Deer

Burning for white-tailed deer has been limited in Wisconsin (W. A. Creed, personal communication, 1966). However, burning for other species has undoubtedly benefited deer.

Deer hunters have been enjoying good hunting seasons in recent years (Rollmann and Hartman, 1965). G. F. Hartman (personal communication, 1960) has stated that in places like west-central Wisconsin, management problems are not centered around deer production, but rather in keeping the herd within the limits of its food supplies by regulating ample yearly harvests. As a result, there has been little interest in fire as a tool in deer management except recently in north-central Wisconsin. In the spring of 1966, a 120 acre burn was conducted by C. A. Botwinski in the Northern Highland State Forest for the purpose of perpetuating an aspen stand. In heavily wooded parts of northern Wisconsin, food shortages for deer are being created as aspen forests succeed to hardwood sites (Hine, 1962). Aspen (Graham *et al.*, 1963) and jack pine (Horton, 1964) are important browse species. Prior to the 1966 burning, the site had been logged for merchantable aspen and contained varying amounts of residual hardwoods. Fire-kill on the hardwoods was about 99%, thus releasing the resprouting aspen which was stimulated by the fire. Early winter observations indicated that deer use was higher in the burn than in adjacent unburned areas (C. A. Botwinski, personal communication, 1967). Apparently the burn was a success, because additional burns are planned to reduce pole-sized hardwood stands and stimulate jack pine regeneration for deer in north-central Wisconsin.

Grange (1949) used fire extensively to maintain maximum deer populations on the Sand Hill Game Farm. He produced higher deer numbers than were found on surrounding similar range (De Boer, 1962) by using fire to regulate plant succession.

Deer have been shown to respond best to the browse plants available in the early stages of succession or to those of fire-type communities (Dahlberg and Guettinger, 1956). Swift (1946), Habeck and Curtis (1959), and McCabe (1964) have pointed out the relationships of deer to fire and the importance of fire in bringing woody plants within reach of deer.

To my knowledge, quantitative research on Wisconsin deer responses to burning are lacking. However, studies such as the one included in Keith McCaffery's and William A. Creed's 1965-66 annual W.C.D. progress report (unpublished) indicate the response of deer to burning.

> On August 30-31, 1965, twenty miles of sandy roads were dragged in Burnett County. Ten miles were located within the Grantsburg Burn (1959) and 10 miles were located west of the burn in forest similar to that which existed on the burn area before the fire. Counts were conducted one day following dragging operations. Twenty-two tracks per mile were found outside the burn while 32.7 tracks per mile were found within the burn. These results were highly significant (.01 level) and although this was only one small sample it lends support to the hypothesis that the fire had a favorable influence on the deer habitat.

FIRE MORTALITY

Much of the literature containing descriptions of wildlife losses due to fire has been written more with emotionalism than with scientific objectivity. Some seem to forget that even "Bambi" and "Smokey the Bear" survived the ravaging forest fires. Perhaps the best summary on this subject is given by Leopold (1933) in his section on fire mortality.

Wisconsin game managers, with the help of James B. Hale, supplied some of the following cases in which wildlife was killed in controlled burns.

Grange reported finding a mallard nest with two eggs that was destroyed in a 1939 control burn. He stated:

> It seems to me that the ducks had just got there, yet they were, almost instantly, about their nesting. With this in mind, I did very little spring burning thereafter, confining almost all burning to the fall period, or to late winter (personal communication, 1966).

J. Berkhahn confirmed this by stating:

> The greatest direct loss to wildlife that I have seen has been the destruction of early woodcock and mallard nests in early April. We normally curtail our spring burning after the middle of April, but even prior to that there is some nesting already underway in some years.

I feel that minor wildlife loses should not be considered, however, if it means burning at times when the effects on the vegetation will be reduced or lost. Rescheduling a burn to eliminate wildlife damage may actually indirectly increase wildlife losses, far and above the casualties incurred, by having the site succeed to a vegetational stage with less productive habitat. N. Stone stated that his early spring burns do occasionally destroy nests, but he felt that most of these ducks renested. He stated that mortality usually resulted when the Forest Protection Division postponed the burning time. The spring zephyrs that usually bring the ducks also bring warm drying weather which melts the last snow and permits favorable burning conditions. This is the most likely time that natural spring wildfires occurred before the advent of man; a time to which the native wildlife species undoubtedly became adjusted. However, Forest Protection usually considers these as high hazard days and prohibits burning (Schroeder, 1950). Stone suspected that fire destruction of early duck nests actually increases duck production by forcing later nesting which is less subject to frost kill and crow predation.

Another possibility is that some of the eggs in burned nests are still viable. Hodson (1965), for example, reported that four mallard ducklings hatched out of a nest with seven scorched eggs. This happened five days after the surrounding vegetation had been burned. B. L. Dahlberg also reported that controlled fire destroyed waterfowl nests, as well as nests of ruffed and prairie grouse.

An interesting incident concerning prairie grouse is related by J. Berkhahn:

> The only loss observed was one crow flying over the area, which after much laboring flight dropped into the burn; two sharptails were seen as they flushed from the path of approaching flames; both sat very tight as if they were nesting. Both of these areas were carefully checked, and no nest destruction was found (intra-department memo, May 9, 1957).

The strange and often erratic behavior of wildlife in the face of fire might be produced more by the presence of firefighters or bystanders than by any innate fear that the game might have of fire (Leopold, 1933).

M. Morehouse observed fire-killed porcupines and cottontail rabbits. After the 1966 fall peat fire which blew up into a wildfire, a hunter bagged an apparently healthy buck deer that had huge scabbed blisters where the hair had been burned from his back. In this same management area, research has commenced to study the effects and magnitude of ash deposits on flowage and pond basins. In addition, ash tests will be taken of at least 35 common plants. In this connection, recently, Johnson and Needham (1966) completed a study of a California stream two years after a burn and found that the fire had essentially no effects. W. C. Truax observed charred mink and muskrats in Horicon Marsh burns. I commercially trapped both burned and unburned cattail marshes on Maryland's Western Shore for two seasons and did not encounter any fire-killed rats, and can attest to the increased muskrat yields and ease of trapping in burned marshes.

Several game managers had not observed any fire mortality in their burns. Many reported seeing deer, grouse, and pheasants moving ahead of the fires.

The majority of managers observed dead mice in the burns. Grange (1949) reported that fire killed some rodents directly and left others without cover. I discovered several dead mice while picking up pyrometers from a University of Wisconsin Arboretum burn several years ago. In my haste to bring back evidence that fires can be destructive, I failed to recognize, until later, that these mice were partially decomposed and had died while the area was still snow covered. I observed numerous mice as they dashed back through the advancing walls of fire and scurried around on the smoking ground during several Wisconsin fires. Sample captures revealed no fire injury in terms of singed hair or burns. In short, I suspect that some of the mice observed in burns had died prior to the fire and became conspicuous when uncovered by it. Other dead mice may have been weakened by high populations and low food supplies, and the fire produced stress, shock, and subsequently death, not death directly by burning.

Fire mortality, then, does occasionally occur in controlled burns, but the number of casualties is usually negligible. Care should be taken in assessing wildlife damage because mortality may, in some instances, be a result of other factors than fire. Quantitative surveys are needed to obtain adequate data on the presence or absence of kills in fresh burns. Lastly, I believe that most wildlife managers would agree that the beneficial effects of burning far outweigh and offset any direct wildlife losses.

On occasion, the fire destruction of habitat may indirectly destroy the wildlife dependent on that habitat. Extremely large burns may reduce protective cover to a minimum. In this connection, I have heard managers speak with dismay of a particular area which was not uniformly burned because the fire missed here or there or didn't burn hot enough in places. Perhaps this is a carry-over from plowing straight furrows or planting trees in rows. The variety of intensities and the spotty effects of fire on a given piece of terrain is to be desired, since this provides the greatest variety in plant succession and edges. Fire has a better "feel for the land" than a man with a spray gun, brush saw, or bulldozer, and leaves or skips the proper amounts and kinds of cover.

The last point concerns fall and winter burning; times when escape and protective cover become critical for many species. Extensive fires or burns that eliminate all the cover in a given area at these times could be damaging to wildlife. This could certainly happen on many southern Wisconsin public hunting grounds where small marshes, the only winter cover available, are like oases in the surrounding biological deserts of crop lands. Fall and winter burning of these marshes would put other wildlife in the same disasterous position as a "runner muskrat" when it has been frozen out of the autumnal pond mistakenly selected for overwintering. In short, late fall burns in areas with limited cover may leave wildlife "out in the cold" where it will be exposed to native and feral predators, poachers, and the elements.

VEGETATION RESPONSES TO FIRE

The vegetation of Wisconsin consists of a variety of types ranging from boreal forest, northern pine-hardwoods, pine and oak savanna, and southern hardwood forest to prairie and wetlands. These major units can be subdivided into 20 or more plant communities (Curtis, 1959). Some of these are minor, have been eliminated by agricultural expansion, or are utilized intensively for forestry, and therefore, are of little concern to the game manager. Fire and its effects must be considered separately in each plant community in which fire is used as a management tool. Even within individual vegetational types, each piece of land to be burned must be assessed separately as to the burning plan and to the expected results (Grange, 1949). This brings to mind one of the most important ecological principles; that is, that there are no principles. Sometimes in our haste to generalize, we forget about the inherent biological variability present in all of nature and that, in actuality, each marsh, stand of timber, or piece of prairie is unique and must be considered as such.

Plant communities in which fire is most commonly used will be discussed separately.

FIG. 4. Brush prairie savanna recreated by prescribed fires on Crex Meadows Wildlife Area. The tall-grass prairie understory is dominated by big bluestem (*Andropogon gerardi*) and has an overstory of scattered fire-charred scrub oaks (*Quercus ellipsoidalis*).

PRAIRIE VEGETATION

Much of Wisconsin's vegetation consisted of prairie or related vegetation. True prairies were scattered throughout southern Wisconsin (Curtis, 1959). Except for isolated groves of sugar maple-basswood-beach, other southern Wisconsin forest was associated with prairie and was dominated by oaks and hickories. In nothern Wisconsin, the beds of Glacial Lake Wisconsin and Glacial Lake Grantsburg were occupied by brush prairie savanna (Fig. 4). This formation consisted of tall-grass prairie species with an overstory of scattered scrub oak (*Quercus ellipsoidalis*) or clumps of jack pine (*Pinus banksiana*) along with isolated red pines (*Pinus resinosa*) (Vogl, 1964c).

All these prairie types have undergone brush and tree invasion since the cessation of fires (Fig. 5). Even in brush prairie savanna where the invasion has been the most complete as a result of 25 to 80 years of fire protection, the canopy has still not eliminated the previous prairie flora (Bray, 1955; Vogl, 1964c).

Controlled burning produces spectacular results. Poor, slow-growing, worthless timber is reduced by fire, and the prairie plants respond immediately (Fig. 5-8). Valuable openings necessary for good game habitat are created, and the game responds. The worthless forests with their high fire hazard, are replaced by prairie or jack pine-scrub oak savannas; communities best suited to the existing edaphic, climatic, and ecological conditions.

Comparisons of burned and unburned brush prairie savanna reveal that spring burning produces more than a 1,000 lb. per acre increase in the above-ground portions of green herbage, with a three-fold increase in grass and forb yield (Vogl, 1965). High annual productivity is maintained for grasses and forbs the second season after burning, but shrubs return to preburn levels. Green herbage is more productive, palatable, and desirable to herbivores because burning increases the water and mineral content.

Dead herbage comprises about 90% of the total yield of stands unburned for 25 years and is reduced to 19% by burning. The removal of dead herbage stimulates earlier and more vigorous growth and makes forage more accessible to game. Repeated burning, up to once every other year, keeps litter at low levels, results in high annual yields, and produced a rapid cycling of nutrients (Fig. 4).

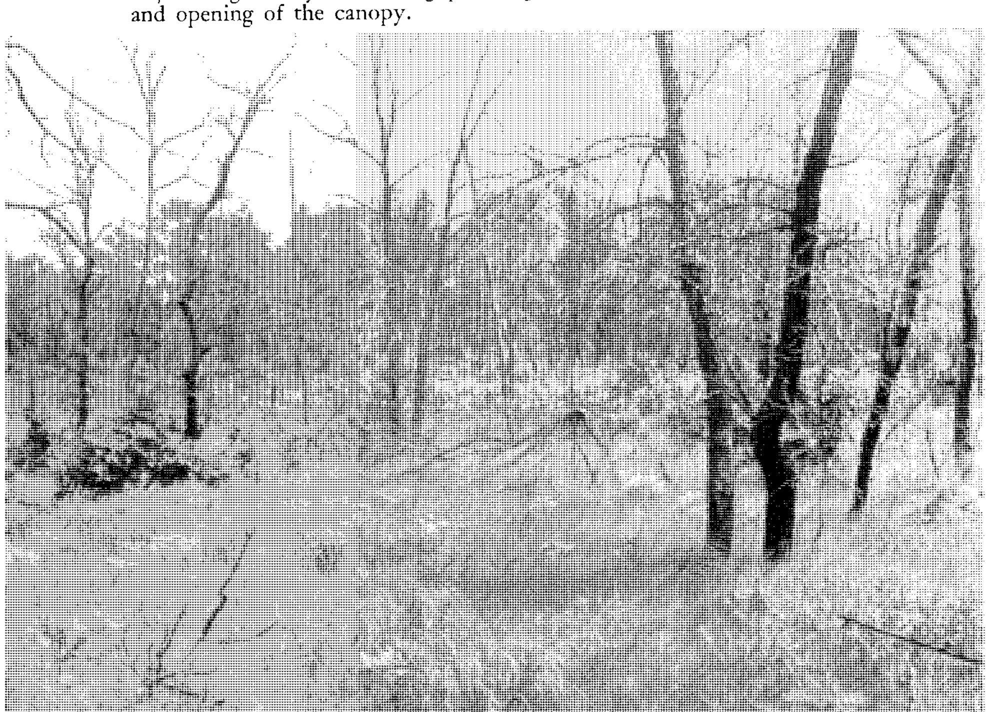
The ground layer vegetation reverts to preburn conditions within four to six years, and burning once during this time helps to maintain maximum productivity. The initial burns in an unburned savanna may have to be conducted almost every other year until the brush is reduced. After that, fires occurring at less frequent intervals, perhaps once every ten years, can be effective in maintaining brush prairie savanna. Periodic burning prevents prairie and prairie savanna from becoming decadent, helps maintain maximum productivity, and is important in retarding the woody growth which otherwise enables savanna to succeed to forest.

Northern Pine-Hardwoods

Much of northern Wisconsin's uplands are covered with hardwood or mixtures of hardwoods and conifers. These communities were opened up by the first logging and post-logging fires, but have since become reforested (Fig. 9).

Fig. 5. A scrub oak transitional forest as a result of 35 years without fire. Reduced prairie grasses and forbs still exist in the forest understory. Monotonous stretches of this forest have eliminated edge-loving and openland game species.

Fig. 6. Same scrub oak forest after one intentional crown fire. Oak trees are resprouting basally. Flowering prairie grasses and forbs have responded to the fire and opening of the canopy.



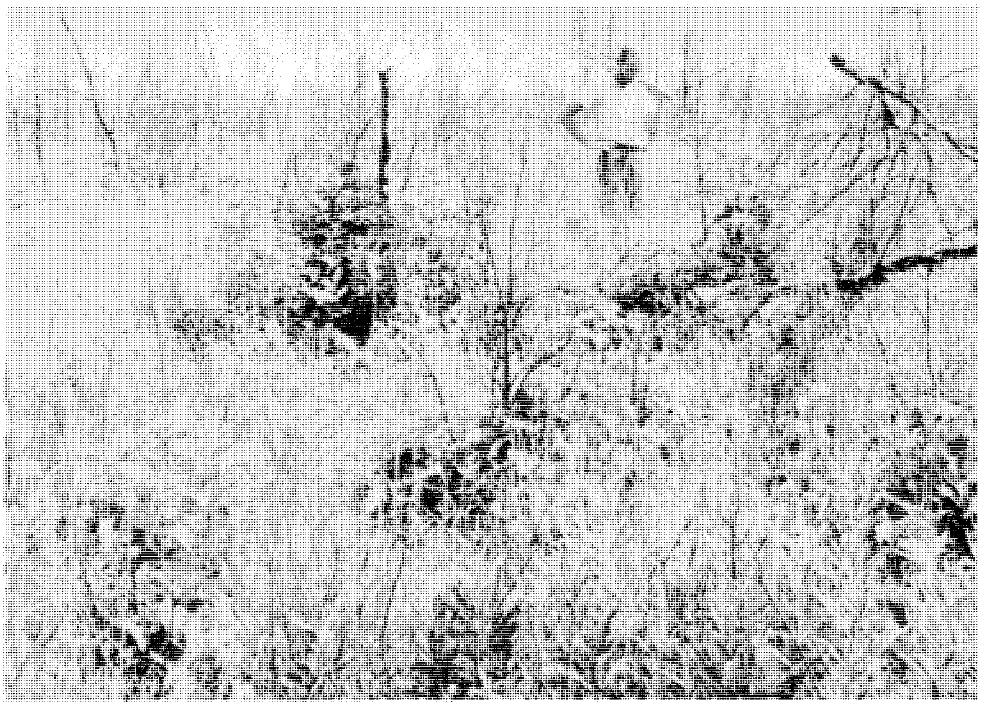


FIG. 7. Same scrub oak forest after three prescribed fires. Oak trees have been reduced to sucker-sprouting grubs. The prairie flora has spread and reached maximum productivity. Openland game begins to respond and utilize these clearings.

FIG. 8. Scrub oak forest (background) has been reconverted to brush prairie savanna by five managed fires. Only occasional low oak grubs dot the tall-grass prairie. Previous forest fuels are almost gone. Wildlife responses are as rewarding as the vegetational responses.

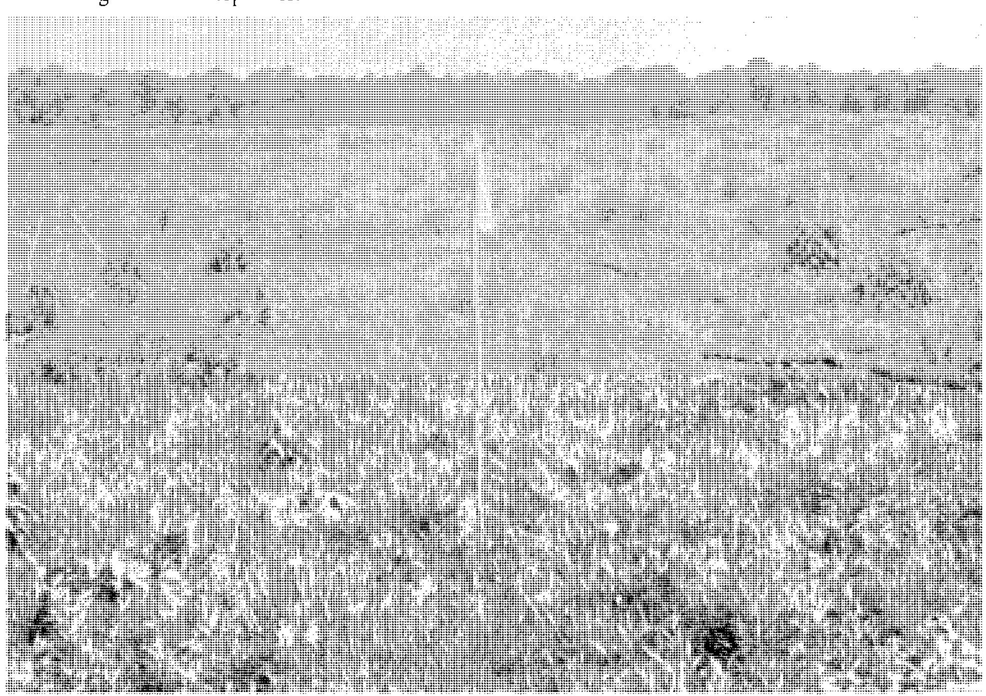


FIG. 9. Intermediate stage of northern pine-hardwood forest occupied by white birch (*Betula paperifera*), red maple (*Acer rubrum*), red oak (*Quercus borealis*), red pine (*Pinus resinosa*), and white pine (*P. strobus*) with an understory of bracken fern (*Pteridium aquilinum*). This, and later successional stages, are almost totally unproductive of wildlife.

These hardwood types are more difficult to burn than most other kinds of Wisconsin vegetation. Stands of mesic hardwoods are often referred to as "asbestos forest" because of prevailing moisture conditions. There are usually only small amounts of fuel on the forest floor. These forests are virtually fireproof except for short periods in early spring and fall when open canopies coincide with dry spells. Best controlled burning results can be obtained at these times. However, when fuels are dry, the fire hazard and chances of a wildfire are greatest. Regardless of hazards, the best openings are created only when a controlled burn reaches wildfire dimensions. Fires started at times when moisture is present are often disappointing in that they have little effect in creating wildlife openings.

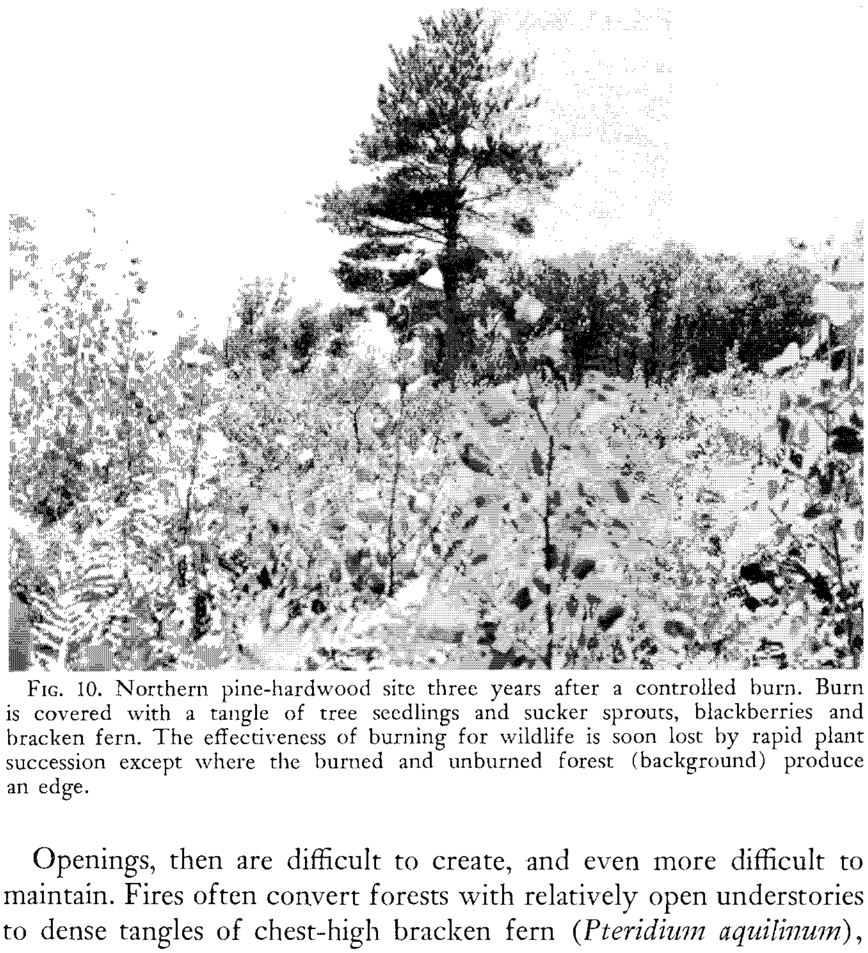


FIG. 10. Northern pine-hardwood site three years after a controlled burn. Burn is covered with a tangle of tree seedlings and sucker sprouts, blackberries and bracken fern. The effectiveness of burning for wildlife is soon lost by rapid plant succession except where the burned and unburned forest (background) produce an edge.

Openings, then are difficult to create, and even more difficult to maintain. Fires often convert forests with relatively open understories to dense tangles of chest-high bracken fern (*Pteridium aquilinum*), blackberries (*Rubus* spp.), and hazel (*Corylus* sp.) crossed with dead fallen snags which quickly become interlaced with resprouting trees (Fig. 10). Many of the plants present are not adapted to fire. Their removal permits the rank growth of pioneer species that respond to the removal of the canopy. Most of the single burns do not transform the site, but only result in a temporary disturbed version of the preburn vegetation. The "jungles" that result would be more effective for ruffed grouse management if small burns could be scattered throughout the forest. This type of burning is not feasible,

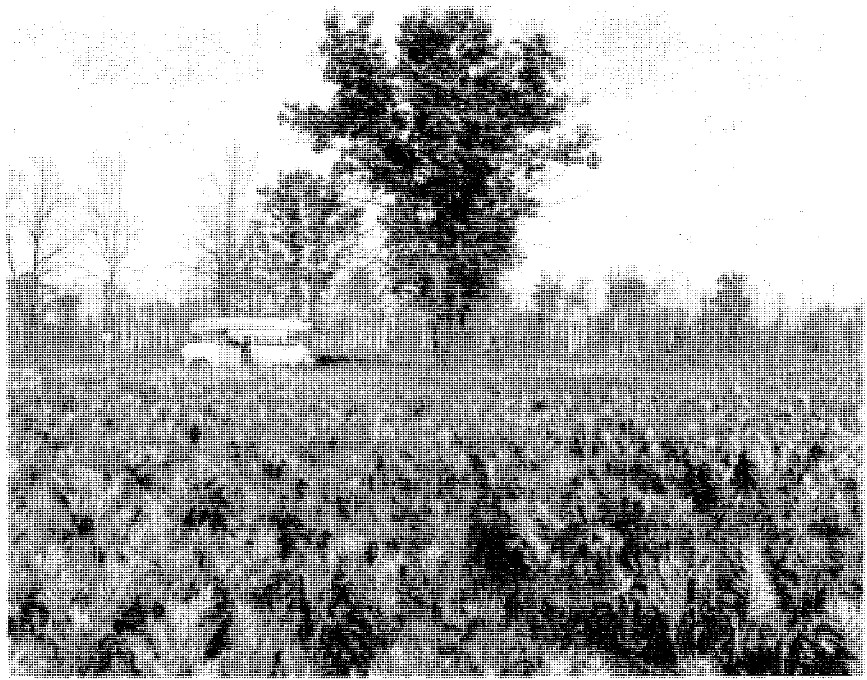


FIG. 11. A burned bracken-grassland dominated by bracken fern (*Pteridium aquilinum*).

however, because of firebreak costs and the high fire hazard. These disturbed sites create browse for deer and food and cover for ruffed grouse, but these effects are lost in a few years. These temporary openings only become effective for openland game and begin to produce valuable edges when the initial burn is followed by repeated fires. If these repeated fires are hot, northern pine-hardwoods can be converted to bracken grasslands, "stump prairies," or barrens.

BRACKEN-GRASSLANDS

Bracken-grasslands have recently been recognized as a major type of grassland in Wisconsin (Curtis, 1959). They occur on open upland sites in the northern half of Wisconsin. These openings are dominanted by bracken fern (*Pteridium aquilinum*) and are generally surrounded by northern pine-hardwoods or boreal forest (Fig. 11).

Most of them came into existence after clear-cut logging followed by fire. Often these post-logging fires were extremely hot due to the accumulated slash, heavy understory of resprouts, and rapid growth of released plants. Such hot fires eliminated any remaining trees and sprouts and completely destroyed the existing understory plants by killing rootstocks and seeds. This permitted an open invasion of grasses and sedges without competition with established species. In addition, since many of these areas developed hardpans while under the influence of forest trees, the elimination of the total vegetation resulted in the appearance during the wet season of surface waters which were normally removed by the transpiring forest stands. The harsh environment, fluctuating seasonally from wet to dry, was best adapted to sedges, grasses, and finally bracken fern. In areas where logging and fire took place in boreal forest and northern pine-hardwood types, few tree species survived since they were either unable to stump sprout after logging or were susceptible to fire, or both. Thus, the tree vegetation was essentially eliminated, leaving the "stump prairies" of today.

Fire is considered to have little effect on the vegetational composition, since it does not substantially alter species composition. The lack of invading species in burned stands indicates burning has not modified environmental conditions or the successional stage.

Fire was observed to have beneficial effects. It stimulated resprouting and early spring growth, increased height of herbaceous growth, and increased flower, fruit, and seed stalk production because of removal of the heavy suffocating mulch and the production of fertilizing ash.

In bracken-grasslands with encroaching trees, fire definitely retards their advance and expands the grassland areas. In most grasslands, several factors operate in combination to maintain them as treeless openings, the most significant being the inability of tree reproduction to become readily established in grassland sod and the inability of trees to become established under the dense, shade-producing canopy cover of bracken fern. In these latter areas only infrequent fire need be used and then only to remove the accumulated rough as well as to stimulate seed and fruit production, particularly blueberries (*Vaccinium* spp.) (Vogl, 1964b).

The game manager's problem is not so much in maintaining bracken-grassland openings, but in making these openings more productive of wildlife (Fig. 12). Intense burns increase Juneberry (*Amelanchier* sp.) and blueberry, excellent grouse and deer foods, and wild lettuce (*Lactuca scariola*) which is heavily browsed by deer. At the same time, these burns tend to decrease bracken fern which has little food value, forms monotonous stands that exclude other species, and which provides no winter or early spring cover.

A big problem still untackled is the creation of new bracken-grasslands needed to support far-ranging species like sharptails and prairie chickens. These openings could be created on sites incapable of producing quality timber. Management plans should simulate the sequence of events that are suspected of having created the original bracken-grasslands; that is, logging and regrowth, followed by severe crown fires. Another feasible method is to salvage timber that has been killed in a wildfire, knock down the remaining snags, allow two years of regrowth, and then reburn under the driest conditions available.

Pine Barrens

Prescribed burning has been conducted for sharp-tailed grouse on barrens in northwestern Wisconsin. The present vegetation consists of a jack pine or scrub oak transitional forest which resulted from the elimination of fires which once maintained these barrens (Curtis, 1959; Vogl, 1961). Originally, savanna-like formations of red pines occurred with large open-grown trees dotting the landscape and towering over the occasional clones of jack pines (Fig. 3). Between the pines and particularly on the ridges, numerous grubs of burr (*Quercus macrocarpa*) and scrub oak occurred. The understory was dominated by blueberry (*Vaccinium anqustifolium*) and sweet fern (*Myrica asplenifolia*).

Fire is presently needed to remove this spreading transitional forest and can be used successfully. B. L. Dahlberg, for example, wrote:

> On April 20th, 1959 on the Namekagon Barrens four (4) of us burned 160 acres. This was a very hot fire with excellent results

Fig. 12. Spread Eagle Wildlife Area, composed of a series of open, upland basins. Bracken fern covers the ridges along with red pine, jack pine, and white birch.

> in setting back an advanced succession of Black Oak-Jack Pine. The area has remained open and would not require a repeat burn until 1970 at least (personal communication, 1967).

This same fire caused quite a stir in northern Wisconsin when it produced an extremely high mushroom-shaped cloud of smoke, and people as far away as Duluth, Minnesota, concluded that "the bomb" had been dropped in Wisconsin.

By allowing an interval of up to ten years between fires, maximum fuels which will carry fires hot enough to reduce oak trees to grubs and to eliminate tree seedlings can be assured. Blueberries and June-berries, common grouse foods, appear to produce maximum yields with several years rest after burning. Barrens, then, can be successfully and cheaply maintained by fire. Since barrens' soils are relatively infertile and incapable of producing timber on an economical basis (Frome, 1962), there should be no delay in reopening and maintaining these barrens with fire so prairie grouse might flourish.

Muskeg or Peat Bog

A muskeg is an open wetlands dominated by a sphagnum carpet growing on compressed and dead layers of peat (Fig. 13). Growing with the sphagnum are sedges (*Carex* spp.), cotton grass (*Eriophorum spissum*), and shrubs such as leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda glaucophylla*), bog birch (*Betula pumila*), and bog laurel (*Kalmia polifolia*). This plant community is scattered throughout the upper Lake States and Canadian provinces where it is often locally abundant. In the Hudson Bay region, muskeg has been recognized as valuable breeding grounds for geese and other waterfowl and has been pointed out as important sharp-tailed grouse habitat (Hanson, 1953). Muskeg in the Lake States is just beginning to be considered for wildlife. Several sphagnum peat bogs are presently under management in Wisconsin to improve conditions for geese, ducks, sharp-tailed grouse, and white-tailed deer. Prescribed burning is used to control the vegetation, and ditching and diking are used to regulate water levels.

Schorger (1944) and Hamerstrom *et al.* (1951) pointed out the potential value of these agriculturally worthless lands by reporting that the original range of sharp-tailed grouse in central and northern Wisconsin was believed to have included areas in and around the edges of open bogs. Hanson (1953) claimed that foods eaten by sharptails are so omnipresent in muskeg that a food shortage for these birds is inconceivable. Minnesota has found larger muskegs to be productive of moose, and with the recent return of moose to Wisconsin (Dahlberg, 1964), muskegs may become important moose habitat.

Despite the potential value of muskeg for wildlife, little has been done in managing these areas beyond some manipulation of water levels. Most of the information on fire in muskegs is reviewed by Ahlgren and Ahlgren (1960). Burning techniques are still experimental. The most intense fires usually occur with the driest conditions of the surface vegetation and underlying peat layers. The drier the fuels, the slower, hotter, and deeper the burn. Most fires are set whenever dry conditions prevail which is usually late summer, fall, or winter. The burning risk is higher than in other vegetation types because of the chance of producing deep, long-lasting, and resurging peat fires, and therefore, requires bold and over-confident men with the torch. This calls to mind the statement made by Stoddard (1962a), "They are too timid, and that's one thing I learned long ago that there's no use trying to make an expert man in the use of fire who has a timidity in his whole makeup."

The high fire danger inherent in peat bogs is illustrated by the 1934 fire in the Powell-Flambeau Marsh that burned almost the entire month of August, requiring that control lines be dug to the sand underlying the peat to prevent the fire spread (Vogl, 1964a). The October, 1966 wildfire on Navarino wildlife area burned over 2,000 acres of swamp as a result of a flare up of a peat fire set two weeks earlier. J. B. Hale (personal communication, 1962) cites a 60 acre control burn on a peat marsh that produced 75 peat fires the next morning that took two days to control.

The ideal way to burn peat vegetation safely is to be able to control water levels. On the Powell-Flambeau wildlife unit, the water is drawn down to the desired level before burning and re-flooded to drown any hang fires. Grange (1949) and Stone (personal communication, 1959) have found that burning muskeg with frozen ground and snow as firebreaks is also fairly successful.

Burning is used to create holes in the peat to produce open water, and to retard and set back encroaching woody vegetation. Trees and larger shrubs are of little food value to waterfowl and the presence of woody plants discourages them from using an area. A reduction in woody plants also encourages sharptails. Burning improves feeding, loafing, and nesting habitat by increasing sedges and grasses and permits freer movement for all game.

Fire has occurred naturally throughout the existence of peat bogs. Peat analyses of bogs or muskegs reveal charcoal layers stratified throughout thin bands of sedge or sphagnum peat (Curtis, 1959). Trees in some bogs are confined to narrow bands ringing open water where they have been able to survive repeated fires. The Powell-Flambeau Marsh was swept by five fires between 1933 and 1948 (Vogl, 1964a). Grange (personal communication, 1966) pointed out that early settlers in central Wisconsin used fires to prevent the invasion of woody vegetation into cranberry bogs. With the arrival of settlers and forest protection to the "northwoods," muskegs and bogs began to be invaded by shrubs and trees. Many of the smaller bogs without open water have been completely filled in by trees in the past 30 years. I have observed a bog in Oneida County change from a sedge-leatherleaf stand to a tamarack-pine forest in 20 years. The ruffed grouse in the area have been replaced by sparrows and chickadees. Numerous small openings like this once dotted northern Wisconsin, and now are being lost along with their edge effects for wildlife. More forest, in this already endless forest, is about as desirable, from a game management standpoint, as ants at a picnic.

An evaluation of the burning on the Powell-Flambeau wildlife unit indicates that fire is not only preventing or retarding succession, but may be reversing it (Vogl, 1964a). Burning tends to reduce conifer swamp to open muskeg and this, in turn, to sedge meadows (Fig. 13, 14). Sedge meadow, by its nature, supports a minimum of woody vegetation; usually no trees and few shrubs. This is far more desirable for encouraging the movement, feeding, and nesting of game birds than is the dense, almost impenetrable mass that woody shrubs form in some muskegs. Even where burning does not cause the conversion of open muskeg to sedge meadows, fire is beneficial in eliminating dead and dying woody stems and branches, reducing the "rough" produced by non-woody herbs, and stimulating new, fresh growth of all plants. Burning also tends to improve game habitat with the production of foods by the stimulation of new, edible woody growth and by a general increase in fruit and seed production. Some of the other changes are slow and subtle and can only be measured by long-range studies.

WETLANDS

Thousands of acres of open marshland have been and still are succeeding to shrub communities or lowlands forests. These shrub communities have been called shrub-carrs (Curtis, 1959). This term designates wet-ground plant communities dominated by tall shrubs, principally willows, with an understory intermediate between meadow and lowland forest.

FIG. 13. Red and white pine, along with tamarack and bog birch shrubs, are encroaching on a portion of Powell-Flambeau Wildlife Area not burned since the 1934 wildfire.

FIG. 14. Prescribed burning has eliminated encroaching trees, reduced the woody vegetation, and converted this area of muskeg bog to northern sedge meadows.

FIG. 15. Prairie winds are again able to rake vast fetches of openlands as a result of the intensive fire management on Crex Meadows. This tract of marsh has been kept open and productive by repeated burning.

Open marshes are most productive of waterfowl, geese, shorebirds, muskrats, and prairie grouse (Fig. 15). Transitions between open marshes and shrub-carrs are more productive of pheasants, woodcock, ruffed grouse, and rabbits. Lowland forests are unproductive of game; dismal forests in which even the lowly rabbit has left and in which the squirrel has not yet arrived. Game managers and sportsmen agree that the early stages of wetlands succession are the most desirable. These communities are important for game in southeastern Wisconsin where they are numerous (White, 1965). Many are owned as W.C.D. public hunting grounds and are heavily hunted because of their proximity to high population centers.

When Wisconsin was first settled, it was commonplace for farmers to burn their wetlands to facilitate haying operations (White, 1965). Lowland forests were occasionally burned by wildfires. Land uses and practices have changed and most marshes are no longer purposely burned. As a result, little is known about the effects of fire and marsh burning techniques. The most extensive burning conducted in southern Wisconsin in the past 20 years has been on Horicon Marsh. Burning has been used to provide spring goose pasture, control brush invasion, and retard duff accumulation on the marsh floor (Truax and Gunther, 1951).

Both prescribed and wildfires have, on occasion, produced undesirable results. Marshes have been converted to sterile beds of nettle (*Urtica* spp.), wool grass (*Scirpus cyperinus*), fireweed (*Epilobium anqustifolium*), goldenrod (*Solidaqo* spp.), or steeplebush (*Spiraea tomentosa*). Fires have been long lasting, hard to control, and have become local nuisances by producing ground-hugging and choking smoke. J. B. Hale (personal communication, 1962) claimed that in shrub communities in central Wisconsin, fires hot enough to destroy willows resulted in an undesirable production of weeds instead of grasses.

To learn more about the fire behavior of southern Wisconsin wetlands, a study of 130 years of plant succession was completed on a Jefferson County lowland in 1966 (Vogl, unpublished). Preliminary examination of the data reveals that the combination of lowered water tables and infrequent peat fires actually accelerates plant succession. Lowlands subject to deep-peat burns do not always stagnate in worthless stands of nettle. Often the peat fires convert sedge meadows or early shrub-carrs directly to aspen forest. The aspen soon becomes underplanted by hardwoods. Results indicate that the most effective fire management of wetlands is repeated surface fires, preferably while the marsh is still open. K. L. White (personal communication, 1967) suspected that repeated burning was also necessary to check or set back plant succession on shrub-carrs.

The problem, particularly in the later stages of succession, is developing burning techniques that will minimize the chances of surface fires becoming widespread peat fires (Conway, 1938). As plant succession progresses, the wetlands become less productive for wildlife. More importantly, from the management standpoint, advances in plant succession result in increased fire danger. Decadent shrub marshes are particularly vulnerable to wildfires (Fig. 16). Overmature aspen stands make wildfires almost inevitable. Where elms have invaded, the wildfire potential has gone beyond normal bounds as a result of the spread of Dutch elm disease throughout Wisconsin's lowlands. More than likely, the ultimate result will be a wildfire. This will probably be a hot sterilizing fire that will develop into a

FIG. 16. Fire on a southern Wisconsin public hunting grounds. Many marshes have become choked with willow shrubs and lowland trees. Controlled burns performed under selected conditions and intervals are more effective than the otherwise almost inevitable wildfires which often result in peat fires. Photo courtesy of Wisconsin Conservation Department.

long-lasting peat fire. A peat fire might burn down to the water table recreating open water, but it would most likely retrogress the succession to where it was after the last peat fire. This would rapidly lead to more of the same lowland forest and another peat fire, and it would become a case of one wildfire breeding another. If the lowland stand escapes fire, it will pass on to a hardwood forest. Either way, the wetlands community will be lost as a valuable hunting ground and a producer of wildlife. I believe it is better to gamble with repeated fires and chance losing occasionally rather than never to gamble and lose everything.

BURNING COSTS

Since fire is a natural environmental factor, ecologists have stressed its use in game and land management. Some wildlife administrators, however, stress the use of fire as a management tool only because it is inexpensive. With the help of J. B. Hale, W.C.D. provided some current costs to illustrate burning expenses.

The first burn of 200 acres conducted by W.C.D. in 1941 required five persons and much equipment at a cost of about $0.30 per acre. Grange (1949) felt that this was an abnormally high cost and could be reduced to perhaps $0.10 per acre under favorable conditions.

The average cost for 8,783 acres burned in northwestern Wisconsin was $0.68 per acre. Costs ranged from a high of $8.30 per acre on a 3.7 acre burn to $0.05 per acre on a 1,940 acre fire on sandy soils. Preliminary results indicate that costs for heavy soils will average between $1.00 to $1.20 per acre. Firebreak costs on light soils averaged $122.21 per mile on a total of 26.5 miles. All of this expense, however, cannot be charged to burning since the breaks are also used for permanent access (Dahlberg, intra-department memorandum, 1967). Mr. Stone stated that after firebreaks are established, the Crex Meadows area can be burned for $0.04 per acre.

Burning costs on the Mead Area from 1960 through 1962 ranged from $0.05 per acre on 920 acres to $1.06 on 50 acres, with an average cost of $0.41 per acre for 5,905 acres. Costs included labor, equipment, and supplies. Since these were the initial burns conducted on the area, the costs are somewhat higher than would be expected on future burns over the same acreage. J. Berkhahn stated that best results were obtained at minimal cost by burning 340 acre plots.

M. Morehouse stated that controlled burning costs in Langlade, Shawano, and Marathon counties ranged from $0.19 to $1.77 per acre. Most of these burns were on heavy soil types.

A 190 acre burn of muskeg on Powell Marsh costs approximately $4.00 per acre (C. Botwinski, personal communication, 1967). Burning of a 120 acre logged aspen stand in north-central Wisconsin cost between $5.00 and $6.00 per acre. In west-central Wisconsin 4,730 acres were burned at an estimated cost of from $0.20 to $0.36 per acre (R. Dreis, intra-department memorandum, 1967). Marsh burning in southern Wisconsin is estimated by W. C. Truax to cost between $0.30 to $1.00 per acre.

From these estimates, it is apparent that costs are variable, but tend to decrease with an increase in the size of the burn. The obvious solution to cutting costs is to increase the size of each burn. However, if the burn is increased beyond a reasonable size, the desired effects for game may be decreased as the chance for the creation of edges by a juxtaposition of successional stages is diminished.

Another possible way to reduce costs is to use small burning crews and a minimum of heavy equipment. B. L. Dahlberg (personal communication, 1967) stated, "A small experienced crew can burn large acreages with greater safety than a large inexperienced crew with lots of equipment. In the use of fire as a management tool the degree of experience your crew has is highly important."

BURNING OPPOSITION

The problems of using fire in Wisconsin are probably somewhat intermediate between those encountered in the Southeast and those in the West. Opposition to fire might be partially responsible for the late start of its use in Wisconsin. Early efforts made by W.C.D. were concerned with land acquisition. Not until the vegetation on these lands began to succeed to less productive types, did the state become interested in land management and consequently the use of fire. The early days of W.C.D., like most game departments, were permeated with the idea that complete protection of a wildlife species or its habitat was all that was necessary.

Factors that hindered the use of fire include: (1) opposition of W.C.D. Forest Protection Division, (2) large devastating post-logging fires in Wisconsin, (3) passage of county forest laws, (4) increase of the general fire hazard throughout the state, (5) lack of research data pointing out the beneficial effects of fire, (6) extensive literature on the destructive nature of fires, including the alleged destruction to game, and (7) birth of a generation of people completely ignorant of fire other than its destructive nature.

The opposition exerted by W.C.D. Forest Protection is far from universal and is usually not direct. The problem most often manifests itself in the northern half of the state when a game manager applies for a burning permit to use prescribed fire on a wildlife area. Some Forest Protection rangers fully understand and are sympathetic to the burning objectives. Others are uncertain of the endeavor and only agree because it will give their fire-fighting crews first-hand experience or will reduce the fire hazard in worthless timber types. A few rangers still see fire in any form as their personalized enemy. They are often reluctant to make the weighty decision to issue a burning permit which might ultimately result in a wildfire that might destroy the very timberland that they were hired to protect. Because they are continually denied burning permits or are issued postponements or cancellations, all but the most persistent game managers give up their burning plans and put their crews to work on other demanding projects. When some game managers finally do get to burn, it is usually under less than ideal circumstances; at times of poor burning conditions; times when it does not benefit and may even be somewhat harmful to wildlife; or at times when the desired effects cannot be obtained. As a result, little is known of the art of burning because selection of different burning conditions is completely restricted. Stoddard (1962b) and Grange (1948) emphasize that understanding basic burning techniques is of prime importance if progress is to be made in the field. Part of the problem is summarized by L. J. Lintereur, game manager, who wrote (intra-department memorandum, 1966):

> Dunbar is another case in point. We conducted a series of control burns on this area. However, the burning situation is such that with the high hazard areas encroaching the Dunbar openings, we could not set our fires on a high hazard day. Thus, the burns here were, in effect, sanitation burns that, if anything, burned the duff in the sedge areas and had no effect whatsoever on the aspen groves and oak edges that surround and are dotted through the openings. Had these burns been of a magnitude that they could have swept through the encroaching area, we certainly could have benefited the population [sharptail] more than we did.

Lintereur concluded:

> In any event, given the result of the past burns and the conditions that we are necessarily held to on this area, I do not plan any future fires on this sharptail unit.

In the light of the Wisconsin burning requirements, it is almost amusing to read Stoddard's (1964) complaint of the Southeast requirement to notify a fire control unit and adjoining landowners before an individual plans to burn. He stated, "By the time this has been attended to, the 'just right' burning conditions following a shower may have become too dry to burn safely." Some Wisconsin burners consider themselves fortunate if they can burn within the same month of the time they ideally planned to burn.

From an historical point of view, Grange (personal communication, 1966) summarized the problem by stating:

> In the earliest burning [1939] there was a lack of cooperation from the fire protection authorities, and a very negative attitude, evidenced by extreme reluctance to issue 'burning permits.' I do not recall, offhand, when the permit system began, but I was refused a permit and did not clear the matter up until I made a trip to Madison and lodged a protest, and a demand, with the superiors of the local personnel who were obstructing my plans and work. Once the ice was broken, the situation changed and, in the end, [1950's] the burning work was at least tolerated and, ultimately, endorsed as a good thing, particularly from the fire protection standpoint itself. At the start, however, there was quite a lot of hostility to the idea, and to anyone holding such ideas. Many of the local, practical people thought the burning was in the right direction and their thinking was far ahead of that of the authorities.

Although conditions have improved since Grange's first burn, problems still exist. B. Popov, formerly of W.C.D., wrote (personal communication, 1967):

> The only opposition within the Game Division came from those who feared that the fire might get away and forever ruled out its use as a management measure. Forest Protection did very definitely and in fact still does curtail the use of controlled burning in Wisconsin both by its lack of cooperation and its subtle opposition to any kind of wild fire.

J. Berkhahn, in evaluating burning on the Mead Wildlife Area, stated (intra-department memorandum, 1967):

> While burning offers a good cheap management tool the biggest short coming I feel is that it is not dependable. In many instances we are unable to burn at the time of the year or under the conditions that will produce the most desirable effect and we

either are forced to wait or burn under poor conditions with only limited results. In too many instances time is already against us and the delay of a year or two or three may practically eliminate the need for burning.

In summary, the personnel of the W.C.D. Game Management Division should be given credit for their persistence in the use of fire as a game management tool despite the obstacles. Today, it takes courageous men to put a torch to Wisconsin woods and fields because they have become tinder boxes filled with prodigious amounts of highly flammable fuels as the result of years of accumulation.

THE FUTURE

The burning program in Wisconsin appears to be improving despite various problems. Indications of a promising future are that most game managers are willing to use fire and that there has been a substantial increase in the acreage burned in recent years. In addition, W.C.D. Game Division has sponsored and supported basic fire research, the Forestry Division is contemplating the use of fire in forest management, and the Forest Protection Division is not only cooperating, but is also actually assisting some game managers with their burning. But, in order to insure a continued bright future, increased efforts must be put forth. These should include: (1) additional basic research on the effects of fire on the vegetation and wildlife, (2) the continued experimentation, establishment, and documentation of burning techniques, and (3) the improved fire education of W.C.D. personnel and the public.

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