FIRE AND WILDLIFE IN WETLAND ECOSYSTEMS

a preliminary bibliography

with abstracts

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Fire is a tool in the management of many units of the National Wildlife Refuge System. Service policies for the management of fire are provided by the Refuge Manual: 6 RM 7. Therein, policy and operational requirements for fire management planning, fire suppression, prescribed burning, fire rehabilitation, fire reporting, and other aspects of the management of fire on Service lands are provided.

Although fire as a habitat management technique has been applied to almost every type of ecosystem at some time, detailed knowledge of fire and its effects upon wildlife and wildlife habitat has largely been obtained from terrestrial ecosystems, most notably forests and grasslands (see references listed in 6 RM 5). Much Fish and Wildlife Service concern, however, is with wetlands and other aquatic or semi-aquatic ecosystems, for which far fewer data are available on the effects of fire. Partially as a reflection of this lack, fire is mentioned only briefly in the Marsh and Water Management section of the Refuge Manual (6 RM 2.5A) as follows:

> "Burning can often be used to set back or keep vegetation succession at a desired stage. It also promotes a rapid return of nutrients to the marsh ecosystem."

The Refuge Manual provides neither details on the use of fire to manage wetland habitats nor guidelines on the development of optimum fire management programs for these ecosystems. Reasons for this are at least twofold: site-specific aspects of fire application prevent formulation of firm generalities, and there is a paucity of data on the subject, scattered throughout the biological literature. To partially remedy the latter problem, and to assist refuge managers in the development of management plans which address effects of fire on their wetlands and wetland wildlife, the following preliminary bibliography has been prepared.

For publications to be included in this bibliography, they had to address the use or the effects of fire in wetland ecosystems. Wetlands are defined as "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" (Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Fish and Wildlife Service, FWS/OBS-79/31. 103 pp.).

A primary data source for this bibliography was FIREBASE, a computerized database covering all aspects of wildfire and prescribed burning, developed by the U. S. Forest Service (Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory, Missoula, MT 59801). Other sources included: the U.S. Fish and Wildlife Service bibliography on the subject prepared in the mid-1970s (Rutkosky 1978), Proceedings of the Annual Tall Timbers Fire Ecology Conference (1962-1976), Wildlife Abstracts (1961-1975), Wildlife Review (1976-1982), the Journal of Wildlife Management (1967-1982), Transactions of the North American Wildlife (later Wildlife and Natural Resources) Conference (1960-1982), Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners (1970-1980), and other documents cited in books and key papers which came to our attention during literature review. This bibliography thus covers the literature available through 1982 and is an attempt to be as complete as possible. Some of the pertinent literature has undoubtedly been overlooked, however, despite best efforts to locate every relevant document; thus the "preliminary" caveat applied to the title.

The abstracts provided herein were obtained from several sources. When possible, authors' original abstracts or summaries were reproduced (denoted as "Author's abstract"). We occasionally modified these for clarity or brevity. If no abstract or summary was available, we prepared one (denoted as

"Kirby and Lewis"). In several instances, original publications could not be obtained and abstracts were taken from Rutkosky (1978) or FIREBASE.

Art Belcher and John Cornely are acknowledged for their review and comments on this document. The assistance of librarians at the Department of the Interior Natural Resources Library is appreciated.

BIBLIOGRAPHY WITH ABSTRACTS

Anderson, S. H., compiler. 1982. Effects of the 1976 Seney National Wildlife Refuge wildfire on wildlife and wildlife habitat. U. S. Fish Wildl. Serv. Resour. Publ. No. 146. 28 pp.

This publication does not deal specifically with wetlands. However, it is a good example of the approach that should be taken to assess the impacts of wildfires on refuge (and other) lands. Effects on vegetation, mammals, birds, reptiles, amphibians, fish, water quality, and soils were determined. Implications are discussed for the use of fire as a management tool. [Kirby and Lewis]

Baldwin, A. G. 1958. Burned: 12,000 acres - on purpose! Wis. Conserv. Bull. 23(5): 18-19.

This brief, anecdotal account presents an overview of the use of fire as a tool for habitat management in Wisconsin. Periodic burning maintains sedge marshes as open areas useful to wildlife. Used with extreme care, fire perpetuates sphagnum bogs and the sphagnum moss industry. After burning, grass and sedge marshes provide a lush growth of early spring greenery for deer and small mammals. [Kirby and Lewis]

Bendell, J. F. 1974. Effects of fire on birds and mammals. Pages 73-138 IN: T. T. Kozlowski and C. E. Ahlgren, eds. Fire and ecosystems. Academic Press, NY.

Immediate and long-term effects of fire on wildlife are reviewed. Included are discussions of changes in species composition and energy flow following fire, changes in density and overall abundance of wildlife following fire, and various case histories to support the major points presented. The evolution of birds and mammals in burnable habitat including the effects of wildlife upon fire, speciation as a result of fire, and adaptation of birds and mammals to flammable habitat are examined. The only reference to wetlands states that burning results in open water, and encourages seed-bearing plants which are valuable waterfowl foods. [Kirby and Lewis]

Beule, J. D. 1979. Control and management of cattails in southeastern Wisconsin wetlands. Wis. Dep. Nat. Resour. Tech. Bull. No. 112. 40 pp.

Fire has been used on state-owned wildlife areas in Wisconsin to dispose of accumulated cattail debris, to set back succession of woody plants, and to allow accessibility to the marsh surface by birds. Burning is usually begun in late fall after heavy frosts have killed and dried plant tops, and is extended into spring before returning birds begin using this cover for nesting. Burning does not actually control cattail because viable plant parts are normally buried in ice or frozen soils. Only in a dried-out marsh, where fire can reach the peat layer, will cattails be controlled. [Kirby and Lewis]

Britton, C. M., J. E. Cornely, and F. A. Sneva. 1980. Burning, haying, grazing, and non-use of flood meadow vegetation. Oreg. Agric. Exp. St. Rep. 586: 7-9.

This study evaluated the response of meadow vegetation to burning, haying, grazing, and non-use in Malheur National Wildlife Refuge, Oregon. A plot burned in November produced the most herbage of any by the following July, with a yield of 7,230 pounds per acre. Although some plant mortality occurred, those plants remaining were larger and more productive. [Kirby and Lewis]

Buckley, J. L. 1958. Effects of fire on Alaskan wildlife. Proc. Soc. Amer. Foresters. Syracuse, NY. 58: 123-126.

Fire removed woody vegetation and increased the attractiveness of an area in northwestern Alaska to waterfowl. New plant growth started at least 2 weeks earlier in the burned area, resulting in an increase in ducks. Early nesting waterfowl ordinarily have higher production, especially in areas with a short season, such as the study site. [Kirby and Lewis]

Bureau of Sport Fisheries and Wildlife, U. S. Department of the Interior. 1964. Managing wetlands for wildlife. Pages 336-346 IN: L. Hoffman, compiler. Project MAR. The conservation and management of temperate marshes, bogs, and other wetlands. Vol. 1. Proc. MAR Conf. organized by IUCN, ICBP, and IWRB at Les Saintes-Maries-de-la-Mer, Nov. 12-16, 1962. IUCN Publ., New Ser. No. 3.

Justification for wetland management is presented, along with the principal management techniques employed. These techniques are classified as: mechanical, chemical, biological, and cultural. The discussion of controlled burning (a cultural technique) discusses the usual desirable results obtained. [Rutkosky]

Burgess, H. H. 1969. Habitat management on a mid-continent waterfowl refuge. J. Wildl. Manage. 33: 843-847.

Management practices used to increase waterfowl use of Squaw Creek National Wildlife Refuge, Missouri, are described. Prescribed winter burning, summer grazing or haying, and fall flooding proved to be an excellent sequence for converting wet prairies into migrant waterfowl habitat. Fire removed overstory or altered plant succession prior to employment of the other techniques. [Kirby and Lewis]

Cartwright, B. W. 1942. Regulated burning as a marsh management technique. Trans. N. Am. Wildl. Conf. 7: 257-263.

Spring fires are set in Manitoba marshes to burn stubble prior to seeding or summer fallowing and to facilitate muskrat trapping. Improved nesting cover also results, enhancing waterfowl production. Adverse effects of fires on breeding waterfowl are counteracted by: 1) obtaining cooperation from hay-claim owners and muskrat trappers, 2) appointing resident fire guardians to regulate hay-burns, supervise fire lane construction and curtail illegal fires, and 3) completing burns prior to the start of duck nesting. [Author's abstract]

Chabreck, R. H. 1976. Management of wetlands for wildlife habitat improvement. Estuarine Processes (J. Estuarine Res. Soc.) 1: 226-233.

Population levels of sporting and commercial wildlife species occupying wetlands are a product of the quantity and quality of habitat available. The rapid loss or modification of wetland habitat by other land-use practices has increased the need for special management to maintain or improve quality. Habitat management practices should be designed to regulate the species composition, density, and distribution of plants. Major factors affecting plant growth in coastal wetlands are water levels and salinity, and the management practices applied should be those best suited to local conditions for maintaining these variables within acceptable limits. Burning has been used as a marsh management procedure. Questions are raised as to the value of this practice overall, and the suggestion is made that burning should not be substituted for water level and salinity manipulation in vegetation management. [Rutkosky]

Conway, R. C. 1938. Marsh burning. Wis. Conserv. Bull. 3(7):9-10.

This paper contains a brief, anecdotal account of the effects of marsh fires in Wisconsin. The general conclusions are that the degree to which these fires destroy game cover, food, and game itself depends upon the time of year, size of the fire, general condition of the marsh, and weather. Spring burns reduce waterfowl nesting success. [Kirby and Lewis]

Cornely, J. E., C. M. Britton, and F. A. Sneva. 1983. Manipulation of flood meadow vegetation and observations on small mammal populations. Prairie Nat. 15: 16-22.

This study compared the effects of manipulating flood meadow vegetation at Malheur National Wildlife Refuge, Oregon, by burning, haying, and grazing. Responses of small mammals, which comprise a portion of the raptor food base, were also monitored. Fall burning decreased accumulated litter and standing dead vegetation, resulting in the greatest subsequent vegetation yield and height of any treatment. Fire induced immediate reductions in small mammal numbers by altering habitat, but populations had recovered by the first post-burn growing season. [Kirby and Lewis]

Cypert, E. 1961. The effects of fires in the Okefenokee Swamp in 1954 and 1955. Am. Midl. Nat. 66: 485-503.

During an extended drought, five major fires occurred in the Okefenokee Swamp of Georgia and Florida. Over 318,000 acres of the swamp and 140,000 acres of adjacent upland were burned. There was considerable destruction of pine timber on the upland, and some damage to the cypress and blackgum forests within the swamp where pockets of peat were burned out. But the belief that the whole character of the swamp had been altered was erroneous; most of the area was only lightly or moderately burned. Coppice growth rapidly replaced the timber which was killed in the more severely burned areas. The number of otters, racoons, snakes, and most fish was drastically reduced during the drought. Alligators, sandhill cranes, herons, waterfowl, and bears were not adversely

affected and some of these may have actually been favored. Recurrent droughts and fires have long played an important part in the ecology of the swamp as is evidenced by charred stumps embedded in the peat and by charcoal deposits several feet below the surface. [Author's abstract]

Czuhai, E. 1981. Considerations in prescribing fire on National Wildlife Refuges. Pages 37-40 IN: G. W. Wood, ed. Prescribed fire and wildlife in southern forests. Belle W. Baruch Forest Science Institute of Clemson University, Georgetown, S.C.

Although this publication does not deal with wetlands, it reviews the use of prescribed burning on southern National Wildlife Refuges. In particular, the beneficial and adverse impacts of fire on forest lands on the Piedmont National Wildlife Refuge, Georgia, are described. [Kirby and Lewis]

Ermacoff, N. 1969. Marsh and habitat management practices at the Mendota Wildlife Area. Calif. Dept. Fish Game, Game Manage. Leaflet No. 12. 11 pp.

Various practices used at Mendota Wildlife Area, California, to control undesirable vegetation and to improve marshes are described. The management practices discussed include the control of winter emergents by burning. [Rutkosky]

Fritzell, E. K. 1975. Effects of agricultural burning on nesting waterfowl. Canadian Field-Nat. 89: 21-27.

Agricultural burning in an intensively farmed region within Manitoba's pothole district is shown to affect the nesting activities of ground-nesting ducks. All species, except Blue-winged Teal (Anas discors), preferred unburned nest cover, although success was higher in burned areas, where predators may have exerted less influence. Attitudes of farmers, burning chronology, and nest destruction by fires are also reported. [Author's abstract]

Givens, L. S. 1962. Use of fire on southeastern wildlife refuges. Proc. Annu. Tall Timbers Fire Ecol. Conf. 1: 121-126.

Prescribed burning is very effective in conditioning upland wildlife and marsh habitat on many southeastern National Wildlife Refuges. It removes dense vegetation (e.g., cattail, Spartina, and giant cut-grass) and accumulated litter. This makes valuable seed-bearing food plants, such as millet and foxtail, more available to waterfowl. Burning also provides succulent sprout growth for browsing waterfowl, e.g., Canada geese. By setting back succession, more productive plant communities can be maintained. As a managment tool, fire is most useful when used in conjunction with flooding and disking. Burning should be done in winter to minimize damage to bird nests. Examples are given of how fire has been beneficial on specific refuges. [Kirby and Lewis]

Gorenzel, W. P., R. A. Ryder, and C. E. Braun. 1981. American Coot response to habitat change on a Colorado marsh. Southwest. Nat. 26: 59-65.

The response of American coot to habitat alteration, including partial and complete drawdown, burning and reflooding, and complete removal of emergents, was studied on a Colorado marsh. Burning of segments of the emergent zone was done in March and April following the lowering of water levels by 30 cm. Burning failed to kill any emergents, but did clear litter from the previous year's growth. Use of the marsh during spring migration was not affected until low water levels exposed emergents. Number of nests decreased from 77 to six following alteration, but increased (56) after reflooding. Alteration also resulted in a delay of five to six weeks in nesting and movement by coots from and to the marsh in response to loss or gain in preferred foods. Increases in aquatic foods after alteration extended fall migration use. Coot populations can be managed easily through habitat manipulation. Activities such as water manipulations, burning, or dredging should be restricted to periods of coot absences. [Author's abstract]

Hackney, C. T. and A. A. de la Cruz. 1981. Effects of fire on brackish marsh communities: management implications. Wetlands 1: 75-86.

This study assessed the effects of winter cover burns on Juncus and Spartina tidal marsh communities along the Mississippi coast. Fire increased the net primary production of the aerial portions of plants in the two marsh types by 56% and 49%, respectively. However, burning altered plant species composition and destroyed biomass destined for export to nearby aquatic ecosystems. The authors urge caution in using fire as a management tool because its effects on all components of a marsh ecosystem are not known. They suggest a management scheme wherein portions of a marsh are burned on a rotational basis, allowing various successional stages to be maintained. This will provide diverse habitats, suitable for furbearing mammals and migratory birds as well as for other life forms not of direct economic importance. [Kirby and Lewis]

Hess, T. J., Jr. 1975. An evaluation of methods for managing stands of Scirpus olneyi. M. S. Thesis, Louisiana State Univ., Baton Rouge, La. 98 pp.

Studies conducted at Rockefeller Refuge, Louisiana, and the Forestry Greenhouse of the L.S.U. Baton Rouge campus are described. They sought to determine the effects of irrigating Scirpus olneyi with varying concentrations of salt water during drought periods, and to determine the response of S. olneyi and Spartina patens to burning under various conditions. [Rutkosky]

Hoffpauir, C. M. 1961. Methods of measuring and determining the effects of marsh fires. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 15: 142-161.

This study sought to devise methods of measuring and evaluating marsh fires and factors affecting them, and to assess their effects in the

Rockefeller Refuge, Louisiana. Post-burn water samples showed increases in pH, sodium and potassium content, chlorinity, and total alkalinity. Most of these increases were greatly depleted after 49 days by tidal action, rainfall, and regrowth. Soil temperatures on burned areas were consistently higher than on adjacent non-burned areas. However, soil temperatures did not increase during burning when the water level was at marsh level or higher. To reduce undesirable plant species, the water level must be below the soil level during burning to insure root damage; otherwise, the burning causes immediate nutrient addition to the soil, promoting the growth of the undesirable species. [Author's abstract]

Hoffpauir, C. M. 1968. Burning for marsh management. Pages 134-139 IN: J. D. Newsom, ed. Proceedings of the Marsh and Estuary Management Symposium. Louisiana State University, Baton Rouge, La.

Three types of marsh burns are described: the cover or wet burn, made in a marsh where water levels are at or above the root horizons; the root burn, which causes damage to plant root systems by fire and heat; and the deep peat burn, which is the result of fire occurring during a very dry spell in a marsh with a peat or mucky peat soil overlaying a clay pan. Management implications are given for blue, snow and Canada geese and pintail ducks. [Rutkosky]

Hovind, R. B. 1949. Controlled burning of public hunting grounds. Wis. Conserv. Bull. 14(4): 13-15.

Controlled burns at Horicon Marsh, Wisconsin, remove plant debris from pond basins, create potholes, stimulate new growth, develop feeding and resting areas for migrant geese, control alder and willow growth, break up monotypic vegetation stands, and reduce the chances of wildfires. [Kirby and Lewis]

Kozlowski, T. T. and C. E. Ahlgren, eds. 1974. Fire and ecosystems. Academic Press, NY. 542 pp.

This review text describes both beneficial and harmful effects of fire on ecosystems and their various components, including soils, soil organisms, birds and mammals (see Bendell 1974), and plants. Grassland, temperate forest, chaparral, desert and desert grassland, and African forest and savanna biomes are examined. The use of fire in land management is also described. [Kirby and Lewis]

Landers, J. L., A. S. Johnson, P. H. Morgan, and W. P. Baldwin. 1976. Duck foods in managed tidal impoundments in South Carolina. J. Wildl. Manage. 40: 721-728.

This paper reports on the relationship between management of tidal impoundments in a South Carolina estuary, vegetative composition in these impoundments, and the diet of wintering ducks using them. Several freshwater peat marshes examined, which were difficult to dry out, were drained as much as possible during the growing season, then burned and flooded in the fall. This encouraged redroot and panic grasses, which were important duck foods. [Kirby and Lewis]

Lay, D. W. 1945. Muskrat investigations in Texas. J. Wildl. Manage. 9: 56-76.

Burning is part of a scheme to manage marshes on the southeastern Texas coast for muskrats. The sedge, Scirpus olneyi, an important muskrat food, is encouraged by burning in late summer. At this time, Spartina patens, the climax species, is set back and the sedge can outcompete it. Spring burns work the reverse. [Kirby and Lewis]

Linde, A. F. 1969. Techniques for wetland management. Wis. Dep. Nat. Resour. Res. Rep. 45. 156 pp.

Controlled burning is one of various wetland management techniques discussed in this publication. This practice is highly effective in: 1) removeing annual "rough" or dead herbaceous cover, thus preventing build-up of debris on the marsh floor, 2) reducing the level of the marsh floor by burning into organic soils, 3) reducing or eliminating woody vegetation in impoundments, 4) destroying sphagnum moss and bringing about succession to sedge and grasses, thus creating nesting areas for waterfowl, 5) cleaning impoundment basins prior to flooding, and 6) producing open areas that will provide better spring grazing for waterfowl. These points are elaborated upon, with special reference to Wisconsin. Techniques for prescribed burning are discussed. [Kirby and Lewis]

Linduska, J. 1960. Fire for bigger game crops. Sports Afield 143 (1): 30-31, 88-90.

This popular article reports on the use of fire as a marsh management tool in different areas of the U. S. On Lake Erie duck marshes, "cold" burning in spring enhances millet, rice cut-grass, and soft-stem bulrush. In the Southeast, fire is used for marsh brush control. Burning along the Gulf Coast simplifies muskrat trapping, reduces the chances of wildfires, and removes debris from saw grass marshes, thereby exposing seed to waterfowl and encouraging new green shoots of wire and salt grasses. [Kirby and Lewis]

Lynch, J. J. 1941. The place of burning in management of the Gulf Coast wildlife refuges. J. Wildl. Manage. 5: 454-457.

Burning is an effective and practical tool in the management of Gulf Coast National Wildlife Refuge wetlands. Marsh fires fall into three classes: cover burns (which may be either clean or spotty), root burns, and deep peat burns. Burning may serve one or more of the following functions: improvement of waterfowl habitat, promotion of waterfowl and muskrat food production and availability, protection from accidental or illegal fires, and facilitation of muskrat trapping. Cover burning, properly done, does not destroy valuable wildlife species, and the inevitable loss of wildlife in root or peat burns is more than offset by improvement of habitat and later gain in the wildlife population. Further experimentation is necessary before Gulf Coast results can be adopted in other parts of the country. [Author's abstract]

McNease, L. L. and L. L. Glasgow. 1970. Experimental treatments for the control of wiregrass and saltmarsh grass in a brackish marsh. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 24: 127-145.

A study was conducted at the Rockefeller Refuge in Louisiana to measure and evaluate the effects of treatments designed to alter natural plant succession and improve the vegetative composition for wildlife. Tilling, burning and tilling, and burning, tilling, and use of chemicals were most effective in reducing the growth of undesirable vegetation and in promoting the growth of a more desirable species, widgeongrass. Reinvasion by desirable species of Scirpus was nil after a five-year period. Chemicals and combinations of burning and chemicals gave good short-term kills; however, after a one-year period the percent kill dropped off appreciably. Fire breaks constructed by a rotary tiller were sufficient in containing all seven of the fires tested in this investigation. [Author's abstract]

Miller, H. A. 1963. Use of fire in wildlife mangement. Proc. Annu. Conf. Tall Timbers Fire Ecol. Conf. 2: 19-30.

Burning in the Horicon marshes in Wisconsin improves waterfowl food suplies and encourages development of needed potholes through peat burns. It also retards the displacement of herbaceous marsh plants by willow-alder brush, which is worthless waterfowl habitat. [Kirby and Lewis]

Miller, W. B. 1962. Waterfowl habitat improvement in California. Proc. Annu. Conf. West. Assoc. State Game Fish Comm. 42: 112-116.

In California, the main value of fire as a tool in marsh management is to periodically reduce the excessive accumulation of emergent plant material which, if left unchecked, would eventually eliminate the ponds. [Author's abstract]

Mook, J. H. and J. van der Toorn. 1982. The influence of environmental factors and management on stands of Phragmites australis. II. Effects on yield and its relationships with shoot density. J. Appl. Ecol. 19: 501-517.

Winter or early spring burning of common reed, Phragmites australis, in the Netherlands did not affect biomass, as measured in late summer. [Kirby and Lewis]

Myers, K. E. 1955. Management of needlerush marsh at the Chassahowitzka refuge. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 9: 175-177.

This study reports on management methods for controlling needlerush at Chassahowitzka National Wildlife Refuge, Florida. Mowing, disking, spraying, burning, and combinations thereof were employed. Needlerush is generally regarded as a weed because it produces little seed for wildlife food, although it does have some value as cover. Burning in early spring increased a useful, competing subdominant, Olney three-square. It also made mowing operations easier. However, it was only effective if used in conjunction with mowing and herbicide spraying. [Kirby and Lewis]

O'Neil, T. 1949. The muskrat in the Louisiana coastal marshes. Fed. Aid Sec., Fish Game Comm., La. Dept. Wildl. Fish., New Orleans, La. 152 pp.

Results are presented on the ecology, population trends, food habits, and management of muskrats in Louisiana coastal marshes. As a management tool, prescribed burning: 1) prevents accumulation of "rough", which if accidentally ignited can do considerable habitat damage, 2) opens up dense vegetation, attracting waterfowl and making marsh travel easier, and 3) sets back succession so that preferred food species such as three-cornered grass can grow. The successional sequence following a deep, peat burn in a sawgrass marsh is described. [Kirby and Lewis]

Perkins, C. J. 1968. Controlled burning in the management of muskrats and waterfowl in Louisiana coastal marshes. Proc. Annu. Tall Timbers Fire Ecol. Conf. 8:269-280.

This paper describes the types of marshes occurring along the Louisiana coast, the vegetation present, and the role of fire in maintaining this vegetation for marsh and waterfowl management. Late September to January burns attract blue (snow) geese. Fire causes muskrats to disperse, thereby facilitating trapping. Burns in early October, before construction of muskrat houses, are desirable. Burning is necessary to maintain three-cornered grass, a preferred muskrat food. [Kirby and Lewis]

Robertson, W. B. 1953. The effects of fire in Everglades National Park. U.S. Dept. Interior, Nat. Park Serv. 169 pp.

Results of studies conducted in the winter and spring of 1951 and 1952 on the effects of wildfire in the Everglades National Park, Florida, are presented. Included are a discussion of the fire history of the Park, a description of inflammable cover types, a discussion of the effects of fire on each of the vegetation types, and a conclusion on the ecological role of fire, the fire problem in the park, and recommended methods of using fire as a management tool. [FIREBASE]

Rutkosky, F. W. 1978. Bibliography on the effects of prescribed burning and mammal and waterfowl utilization of wetlands: annotated literature search with selected abstracts. U.S. Fish Wildl. Serv., Div. Ecol. Serv., Annapolis Field Office, Annapolis, Md. 45 pp. [available in the U.S. Dept. Int. Nat. Resour. Library]

This bibliography contains 176 entries, 47 of which are abstracted. An index lists entries under the topics of fire, mammals, management, prescribed burning, Scirpus olneyi, waterfowl, and wildlife foods. Some foreign publications and dissertations are included. [FIREBASE]

Schlichtemeier, G. 1967. Marsh burning for waterfowl. Proc. Annu. Tall Timbers Fire Ecol. Conf. 6: 40-46.

This study sought to determine whether burning, along with other related habitat manipulation methods, would help to restore for waterfowl use a reed-choked marsh in north-central Nebraska. Dense stands could be burned readily when ice was 23 to 30 cm thick and five to ten cm of snow covered the

surrounding range, preventing ignition of organic soils. Light or moderate grass fuels would not burn under similar conditions. Winter burning reduced reed and bulrush density 60-85%, allowing space for waterfowl movement and activities during summer and fall. [Kirby and Lewis]

Singleton, J. R. 1951. Production and utilization of waterfowl food plants on the east Texas Gulf Coast. J. Wildl. Manage. 15: 46-56.

Thirteen species of waterfowl food plants were examined in the Texas Gulf Coast to determine environmental factors affecting their production. These included water level stability, plant competition, and time of burning. Burning in February had no effect on spring growth and subsequent plant blooming and seed production of leafy three-square or smartweed. Periodic burning of sawgrass made the seed available to waterfowl as it thinned out stands. Burning of marsh vegetation in this area should be delayed in the fall until waterfowl food plants such as millet, smartweed, and salt grass have matured seed and these seeds have fallen. Late winter burning retarded the growth of sawgrass and accelerated spring growth of smartweed. [Author's abstract]

Smith, R. H. 1942. Management of salt marshes on the Atlantic Coast of the United States. Trans. N. Am. Wildl. Conf. 7: 272-277.

The types of management techniques used on an area depend largely on production objectives. Marsh management includes physical improvements or development, and cultural practices. These techniques involve creation of water areas, alteration of salinity levels, damming and diking, burning, harvest of marsh grasses, and direct planting and seeding. Marsh fires can be classified as cover, root, or peat burns. Cover burns are light and usually done between October 15 and March 1. They remove vegetative debris, thereby making food available to waterfowl, encouraging growth of high-grade muskrat and waterfowl food plants, providing succulent grazing for geese in three-square meadows and cattail marshes, and making dense marsh areas accessible to muskrat trappers. Root burns are hotter and are designed to alter vegetative composition through control and replacement of various low-value marsh species. They must be undertaken when the marsh floor is dry to be effective, necessitating care to prevent damage to wildlife. Peat fires burn holes in the marsh floor to provide additional water areas. [Kirby and Lewis]

Toorn, J. van der and J. H. Mook. 1982. The influence of environmental factors and management on stands of Phragmites australis. I. Effects of burning, frost and insect damage on shoot density and shoot size. J. Appl. Ecol. 19: 477-499.

Wet-burning of common reed, Phragmites australis, in the Netherlands caused no damage when done in winter or early spring, before shoots emerged. Burning during the emergence period, however, killed most shoots in wet and dry treatments. [Kirby and Lewis]

Trippensee, R. E. 1953. Wildlife management. Volume 2. Fur bearers, waterfowl and fish. McGraw Hill Book Co., NY. 572 pp.

Fire is mentioned briefly in the chapter of this general text that addresses marsh and swamp management. Surface burns, done when underlying solid matter is saturated, can provide waterfowl habitat and fire protection by removing "rough" debris, encourage lush new vegetation for wildlife food, and facilitate movements of wildlife and people in a marsh. Root burns kill off climax vegetation and can cause deep pits to form in the marsh floor, thus providing open water for waterfowl and fur bearers. After a marsh drys to a depth of six inches, giant cutgrass, reeds, sawgrass, cattails, mints, and river bulrushes can be burned for control purposes. Fires should be set when birds are not nesting and plants are dormant. [Kirby and Lewis]

Truax, W. C. and L. F. Gunther. 1951. The effectiveness of game management techniques employed on Horicon Marsh. Trans. N. Am. Wildl. Conf. 16: 326-330.

Management of semi-aquatic habitat on the Horicon National Wildlife Refuge, Wisconsin, consists, in part, of controlled burning of from eight to ten thousand acres in late fall or winter to: 1) create spring pasture for geese, 2) retard litter accumulation on the marsh floor, 3) control undesirable woody plants, 4) burn out peat holes, and 5) prevent incendiary fires. [Kirby and Lewis]

Uhler, F. M. 1944. Control of undesirable plants in waterfowl habitats. Trans. N. Am. Wildl. Conf. 9: 295-303.

Fire is considered to be "the best single tool available" for controlling undesirable marsh plants. It is inexpensive, easy to use, and highly effective, although it must be handled with care and should not be used during the breeding season. Three types of burns are recognized: 1) surface burns, which are made when water is shallow, to temporarily release valuable plants that have an earlier growing season than objectionable species. These fires make available as food the tender new growth of plants. Cattail and cordgrasses can be controlled and seed production of sawgrass stimulated by such burns; 2) root burns, made when marsh soil has dried to a depth of three to six inches, to control species such as giant cutgrass, reed, sawgrass, cattail, mints, river bulrush, and other unproductive sedges; and 3) peat burns, made only during droughts and when the goal is to convert a marsh into a truly aquatic environment. Solid stands of reed, cattail, and sedges have been converted into productive nesting grounds by such localized burns. [Kirby and Lewis]

Vogl, R. J. 1964. The effects of fire on a muskeg in northern Wisconsin. J. Wildl. Manage. 28: 317-329.

The effects of prescribed burning on marsh vegetation and wildlife were assessed in north-central Wisconsin. Fire produced a conversion or retrogression from conifer swamp dominated by trees to open sphagnum bog or muskeg dominated by sedges and ericaceous shrubs. The muskeg may be

changed further to northern sedge meadows, dominated by sedges and supporting a minimum of woody vegetation. Such meadows are more desirable than other successional stages because they allow the greatest movement, feeding, and nesting of game birds. Fire also improves game habitat by reducing the "rough" of woody and nonwoody plants, stimulating new and palatable growth, and increasing fruit and seed production. [Author's abstract]

Vogl, R. J. 1967. Controlled burning for wildlife in Wisconsin. Proc. Annu. Tall Timbers Fire Ecol. Conf. 6: 47-96.

In Wisconsin, fire historically maintained attractive duck breeding habitat by inhibiting plant succession. Grassy and herbaceous upland vegetation established and maintained by fires provides excellent cover for upland nesting ducks, such as the blue-winged teal and the mallard. In marshes with peat substrates, depressions are created by deep burns in dry years and afford open water when flooded. Fire is also used to clear flowage basins before diking and flooding. The ash promotes growth of desirable aquatic plants. Used in conjunction with water level drawdowns, fire can help create pioneer sites for 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 nongame species like sandhill cranes. Fire is also used to retard hydrarch succession and the advance of woody vegetation. [Kirby and Lewis]

Vogl, R. J. 1969. One hundred and thirty years of plant succession in a Wisconsin lowland. Ecology 50:248-255.

The post-glacial history of a marl and peat marsh in Wisconsin contained evidence that early hydrarch succession may have been relatively rapid due to higher plant as well as invertebrate animal productivity. Pristine open marsh, sedge meadow, and wet prairie were held in quasi-equilibrium by alterations of floods during wet periods and fires during drought. Fires either checked terrestrial advancement or turned it back to earlier aquatic stages by organic substrate removal. Recent fire control and continued lowering of water levels hastened intermediate hydrarch succession by quickly and directly converting aquatic to terrestrial sites. A peat burn increased soil pH and soil nutrients, particularly the phosphates, and eliminated plant competition so that open marsh was immediately invaded by aspen forest, which if uninterrupted, will be converted to lowland hardwood forest. Recurring fires could perpetuate the sucker-sprouting aspen, but burning decadent aspen forest might originate true prairie. Although fire is usually catastrophic and retrogressive, it produced successional stability and even acted as a successional accelerator in this lowland. [Author's abstract]

Vogl, R.J. 1973. Effects of fire on the plants and animals of a Florida wetland. Am. Midl. Nat. 89: 334-347.

Wildlife responses to fire were assessed in a wet prairie along the shore of a large north Florida pond. In the four months following the fire, over

three times more birds were observed on the burned area than an adjacent and comparable unburned shoreline. Only five of the 35 avian species encountered were seen more often on the unburned site. Fire-induced bird and mammal injury or mortality was unobserved even though the burn resembled a wildfire. Birds showed no fear of the fire and some were attracted to the smoking landscape. Although some cold-blooded vertebrate mortality occurred, other herptiles survived, and alligators used the burned shoreline almost exclusively. Mammal populations of burned and unburned areas appeared similar four months after the fire. Animal responses were considered related to the fire removal of the heavy grass mat that otherwise covered the water and soils and the foods contained therein, and physically impaired new plant growth. Burning also produced an earlier, more rapid, and far more productive growth of wet-prairie plants. [Author's abstract]

Ward, P. 1968. Fire in relation to waterfowl habitat of the Delta Marshes. Proc. Annu. Tall Timbers Fire Ecol. Conf. 8: 255-268.

This paper discusses controlled burning as a practical management technique for manipulating cover on the Delta Marsh in south-central Manitoba. Reoccurring fires perform a vital role in removing dense stands of dead and decaying vegetation and in maintaining the climax status of Phragmites. Spring fires remove vegetation but do not affect regrowth. Summer fires, however, can have lasting effects on regrowth. Aspects of marsh burning unfavorable to wildlife are mentioned. The most important are: destruction of nesting habitat during the waterfowl breeding season (forcing birds to concentrate in unburned cover and making them more vulnerable to predation) and loss of the marsh's ability to catch and retain drifting snow. This latter aspect can be vital to marsh survival in areas of low annual precipitation. Conditions for ideal burning and for fire control are discussed. [Kirby and Lewis]

Wright, H. A. and A. W. Bailey. 1982. Fire ecology. United States and Southern Canada. John Wiley and Sons, NY. 501 pp.

This general review text emphasizes the historical and present-day impacts of fire on vegetation, particularly native plant communities. The role of fire in major ecosystems of the U. S. and southern Canada, including grassland, semi-desert grass-shrub, chaparral and oak brush, pinyon-juniper, Ponderosa pine, Douglas fir, spruce-fir, red and white pine, coastal redwood and giant sequoia, and southeastern forest biomes, is discussed. The principles and use of prescribed burning to achieve management objectives are described. Responses of small mammals, birds, big game, fur bearers, stream fauna, and marsh species to fire are mentioned. In wetlands, burning can: 1) make new green shoots and roots and rhizomes of sedges and grasses available to geese, 2) eliminate accumulations of organic matter and impenetrable growth of climax species such as common reed, bulrush, sawgrass, wiregrass, and common cattail, thus increasing wetland suitability for waterfowl and muskrats, 3) allow seeds to become available to waterfowl, and 4) create edge and deep pools for waterfowl nesting and feeding. [Kirby and Lewis]

Yancey, R. K. 1964. Matches and marshes. Pages 619-626 IN: J. P. Linduska, ed. Waterfowl tomorrow. U. S. Fish and Wildlife Service, Washington, D. C.

Fire "is a destroying angel, whose ecological mission it is to cleanse", i. e., to keep waterfowl marshes from becoming brushy bogs or wooded swamps. Root burns set succession back to a subclimax plant community that is more productive of food for waterfowl and more open for feeding. Brackish marshes along the Gulf of Mexico are fertilized by ash deposits left by fire, as these contain potassium, calcium, phosphorus, magnesium, and chlorides. Cover burning eliminates accumulated growth and makes roots, rhizomes, and young shoots available to grazing snow geese. Peat burns create holes in the marsh floor, which become ponds and open water areas. As a waterfowl management practice, fire serves best in a marsh over which water control can be exercised. Burning should not be done during or just prior to waterfowl nesting, unless long-range gains in improved habitat outweigh immediate losses of nests and young birds. "The well-singed (and therefore very cautious) experienced marsh manager sees in every box of matches a Pandora's box of good and evil. The task is to coax out of the box the benefits of fire without setting loose any of its diabolical consequences." [Kirby and Lewis]

Zontek, F. 1966. Prescribed burning on the St. Marks National Wildlife Refuge. Proc. Annu. Tall Timbers Fire Ecol. Conf. 5: 195-201.

Prescribed burning is a management tool used to benefit waterfowl on the the St. Marks National Wildlife Refuge, Florida. Geese prefer marsh areas that are burned. The effectiveness of fire in marsh management often depends on the ability to flood burned marshes before new growth starts. [Kirby and Lewis]