1. Prescribed Fire at Blackwater NWR

Fire was used on what is now refuge lands by native Americans to improve wildlife habitat, for hunting, and land clearing. During colonial times, fire was utilized for farming, for agriculture, and grazing land management. Prior to Federal acquisition, the refuge marshes were managed for the fur resources, primarily muskrat by Delmarva Fur Farms. Marsh burning was conducted to benefit trapping operations. Marsh burning rotations have varied over the years, from 1-3 years dependent on the management goals. In 1976 an annual burn rotation was established to maximize trapper catch and to increase goose browse availability in order to reduce crop depredation on surrounding private farmlands. Burning was conducted primarily by permit trappers. Limited fire suppression ability was available. By 1978, controlled burning was conducted exclusively by refuge staff to reduce liability concerns from refuge fires. Approximately 3000-4000 acres are currently burned annually. In 1994, a cooperative fire agreement with the Maryland Department of Natural Resources (Fishing Bay Wildlife Management Area) was initiated and Blackwater Fire personnel began assisting DNR personnel in annually burning an additional 7000 acres of marshland.

Both ground and aerial ignition using the Premo Mark 3 aerial ignition device (ping pong machine) may be used for prescribed burns. The MD DNR Police Bell 206 Jet Ranger and/or a contract helicopter has been used for aerial ignition.

In 1995, a prescribed fire evaluation of the Blackwater and DNR Fishing Bay programs recommended that an evaluation of various fire frequency regimes be conducted. Six study areas were established (3 on Blackwater and 3 on Fishing Bay WMA) which evaluates no burn, annual burns, 3-5 year burns, and 7-10 year burns. A graduate student has been collecting information from these areas since 1998 and will be publishing a master's thesis, which addresses vegetative response to the listed prescribed burn rotations.

Woodland prescribed burning was utilized on a very limited basis on the refuge prior to 1996. Only about 100 acres of woodland/marshland fringe and transition zones were burned on a three year rotation to reduce fuel hazards. Current woodland burning objectives include hazard fuel reduction to protect endangered and threatened species habitat, habitat enhancement for endangered species (bald eagles and Delmarva Fox squirrel), promote habitat diversity and timber management and assist in the control of phragmites and other exotic species. Prescribed fire in woodlands usually occurs during the dominant period of fall, winter, and early spring. Refuge staff are evaluating fall and late summer prescribed burns for accomplishing objectives.

Grasslands are burned on a as needed basis to maintain grassland habitat and to reduce or eliminate the need for mechanical tillage. An average 80 acres yearly are burned.

Beginning in 2002, wildland urban interface burns are being conducted adjacent to private residences to reduce the wildfire hazard. These burns are being accomplished on both refuge and private lands.

2. Wildfire Suppression

In early years of the refuge, most surrounding landowners burned their marsh to suit their needs. The refuge trappers also burned the refuge marsh as part of their obligations as lease holders. Occasionally fires from private lands entered the refuge or a refuge trapper's fire would escape and burn a neighbor's duck blind or burn into private woodlands. These incidents were infrequent and no major problems were documented. In more recent

years however the complexity of the fire situation has increased due to changes in habitat, land use, refuge visitation, wildlife and wildland significance, and housing/marsh interface. Wildfire risks to public property and wildlife are greater. The refuge's fire suppression equipment was extremely limited, consisting of hand tools and a Willys Jeep with a 100-gallon pumper. After 1978, the refuge took total responsibility for fire management on Blackwater. Any fires set by refuge trapping leasees were technically illegal, although no major enforcement effort was conducted to control this activity. If there was not a threat to public safety, wildlife, or property, these fires were reported as unplanned prescribed burns. Beginning in 1990, these fires were treated as wildfires and an effort was made to document these burns and monitor them in the event that suppression action was necessary. During this time period, Blackwater increased its fire fighting capabilities with additional equipment, manpower, and training. Any fires, which pose a threat to public health and safety, property or wildlife values are aggressively suppressed. Currently the refuge fulfills a more active role with Maryland Forestry Service in supporting and providing assistance to their wildfire program under a cooperative agreement and as partners in the Delmarva Fire Management Group. Blackwater is an active partner in wildfire suppression and is recognized by the Dorchester Volunteer Firemens Association and the Maryland Department of Natural Resources Forestry.

From 1991 through 2001, 153 wildfires have burned 3,470 acres on Blackwater NWR. Causes of these fires and number of refuge acres burned are depicted in Table 1.

Table 1. Blackwater NWR Wildland Fire Occurrence Summary, 1991-2001

CAUSE	NUMBER OF FIRES	REFUGE ACRES BURNED
Escapes from other lands	44	1,400
Arson fires	90	2,065
Pyromania	6	<1
Debris Burning	2	0
Trash Burning	5	3
Lightning	6	2
Vehicle Fire	2	<1
Total	153	3,470

Figure 2 depicts the average number of wildfires per year at Blackwater NWR based on fire reports submitted from 1991 to 2001. Average fire load is illustrated by 10-day period to give some idea of the season of year when fires typically occur.

No prescribed fire program has ever been implemented on Martin or Susquehanna NWRs. There has been no history of wildfires on either refuge.

3. Fire Frequency and Behavior

Prescribed and wildfires occur annually on the refuge and surrounding state-owned and private lands. Refuge prescribed fires in the marsh are conducted during late December through late March. Woodland prescribed fires are conducted in the fall and early spring. Refuge grasslands prescribed burns are conducted as needed throughout the year.

Generally marsh fires (wildfires and prescribed fires) will be head fires (running with the wind) that will race across the marsh surface pushed by prevailing winds and rapidly dissipating whenever vegetation is too broken to sustain the flames because of occurrence of mud flats, water or roads. Backing fires (burning into the wind) are used in prescribed marsh burning to burn out around protection zones such as houses, duck blinds, roads, eagle roosts and nests. They also can be used during wildfire suppression efforts to burn out an area to halt an oncoming flame front. Woodland wildfires can be head or backing fires depending on the circumstances of location. If a marsh fire creeps back into a woodland then the fire will be generally slow-moving and of low intensity. However, woodlands in the path of a running, marsh head fire potentially would burn more rapidly and with higher intensity (depending on fuel loads and fuel moisture). Prescribed fires in refuge woodlands are generally combinations of backing fires and head fires depending on wind, fuel, and site characteristics. Generally such fires are relatively slower moving, of longer duration, and less intense than marsh fires. Fire behavior in prescribed grassland burns would be similar but less intense than marsh burns. If possible, a head fire would be used after back-burning a protection zone. Wildfires in agricultural units would be unlikely.

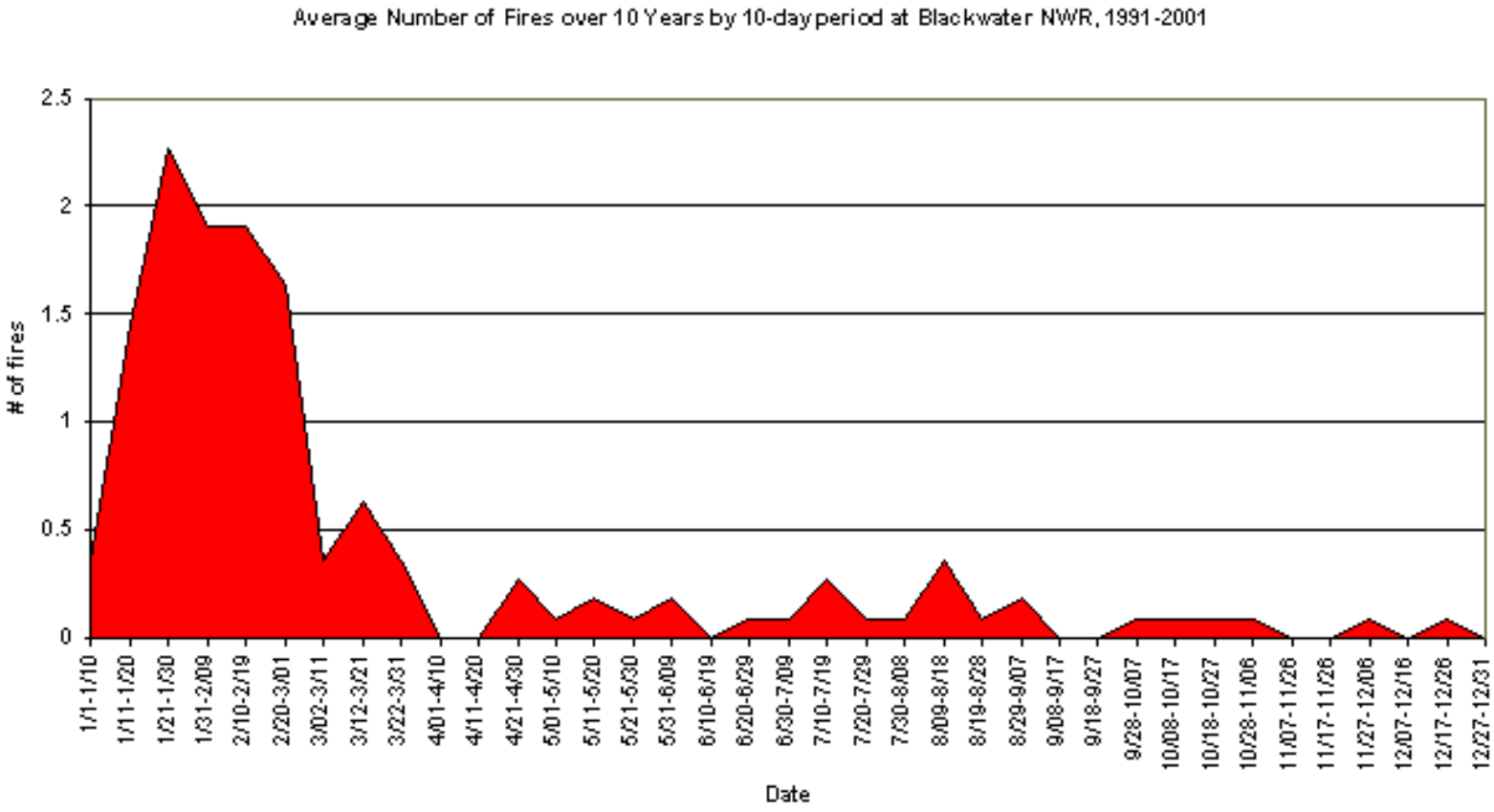

Table 2. Characteristic Prescription Fire Behavior in Marsh, Woodland, and Agricultural Prescribed Burns (based on BEHAVE outputs)

Rx Fire Type	Flame Length (ft)	Rate of Spread (ch/hr)	Fireline Intensity (BTU/ft/sec)
Marsh	6-22	24-303	281-4630
Woodland	0.5-7	0-42	1-364
Grassland	2-8	3-39	38-525

Wildfires burning outside of prescription parameters would be expected to produce more intense fire behaviors than those of predicted prescribed fire behaviors listed above.

4. Fire Effects

A. Vegetation and Fuels -- Marsh fires burning within prescription parameters will result in a cover or surface burn, with resultant stubble 2"-6" in height. Fire will not penetrate the soil to the rhizomanous layer of the

vegetation although heat penetration could occur up to a few inches. Most standing dead herbaceous vegetation will be consumed by the fire. Matted litter will be consumed in varying amounts depending on water depths, and fuel moisture at the time of burn. If the marsh surface is flooded or frozen, most matted litter will not burn. During the burn season, plants are dormant and nutrients and energy will be located in the underground rhizomes; burning will aid in nutrient mobilization and cycling. Due to variations in vegetation density and the presence of natural firebreaks, burn units will rarely, if ever, experience 100% burn coverage. Therefore, the post-burn landscape will contain patches of unburned standing dead vegetation as well as scattered areas of unburned surface litter. In addition, vegetated borders of rivers, creeks, ponds and guts often will remain unburned. Marsh burning will reduce fuel loads in proportion with area of burn coverage and surface litter conditions. Pendelton and Stevenson (1983) documented that above- and below-ground biomass was greater in burned vs. unburned marshes on Blackwater. Root and culm densities, and seed production will be greater in the burned sites. Resprouting of vegetation typically occurs several weeks earlier in burned vs. unburned areas. Annual and perennial plant species occurrence and composition is more dependent on site-species relationships (periodicity and duration of flooding, salinity levels, herbivory) than burning. Annual use of fire maintains herbaceous dominance in marsh/forest transition zones.

Use of prescription fire in woodlands will reduce surface litter and consume some herbaceous and woody growth. Amount of fuel consumption depends on surface conditions, fuel moistures, fuel loading, and green vegetation development. Because of variations in fuel loading and arrangement, and surface water, area burned will not be 100%; patches of burned and unburned vegetation, and dead woody fuels will be present post-burn. Because of soil moisture, fire penetration into the soil is not a concern. Saplings less than about one inch in diameter will be killed. Mortality of larger saplings will be dependent on species, fire intensity and duration of burn. Although trees in the pole and sawtimber sizes will experience some scorching, no mortality of healthy trees will result. Generally loblolly pine will be more resistant to fire than hardwoods. Standing dead snags will often burn and fall during the burn or be more susceptible to wind throw post-burn. Burning will stimulate establishment and growth of herbaceous ground vegetation.

Grassland burns will improve site preparation in agricultural units, will allow better farming conditions at less cost, and result in better crop yields and wildlife food supplies.

The effects of wildfire will be indistinguishable from those of prescribed fire if wildfire occurs under prescription conditions. However, this is usually not the case. Wildfires often occur when location, air temperature, relative humidity, fuel and soil moistures, and wind speed and direction are undesirable. These conditions produce more intense fire behavior and potentially damaging long-term fire effects to soils, vegetation, wildlife, and air quality.

B. Wildlife -- In both marsh and woodland fires, prescription fire effects will benefit the majority of wildlife species using the sites by creating more favorable habitat conditions. However, rarely will any management action be beneficial to all the inhabitants of the management unit. In the marsh, habitat quality will be improved by maintaining or enhancing marsh health and productivity, thereby curbing marsh loss. Food production will be increased. Waterfowl habitat quality will be increased due to increased food supplies and improved stand conditions. Marsh burning facilitates trapping of muskrats and nutria and therefore helps to control their numbers, and in turn, helps protect marsh habitat from overgrazing and deterioration. Marsh maintenance and excess herbivory control will help erosion and water quality, which should create better fisheries habitat and eagle food production. Hazard fuel reduction around eagle nest trees and eagles roosts will help protect these habitat features from losses due to wildfires. Increased carrying capacity of marsh rodents and waterfowl will provide more abundant prey for peregrine falcons, eagles, and other raptors. In the woodlands, burning will increase habitat diversity and wildlife species diversity. Food supplies such as grasses, forbs, soft mast, insects, and rodents will

be increased for a variety of forest-dwelling species. Delmarva fox squirrels will benefit by enhancement of open understory and stimulation of seed producing annuals in the understory. Reduction in hazardous fuel loads will help protect woodland habitats including Delmarva fox squirrel nest and cavity trees; bald eagle roost, perch, and nest trees; and other wildlife features from damaging wildfires.

Agricultural burns will benefit wildlife food production by enhancing site conditions.

C. Air Quality -- The smoke produced by combustion contains particulate matter and gases that are emitted into the atmosphere and therefore reduces air quality. However, prescribed fire activities are planned so that smoke will cause the least amount of environmental impact. Factors that influence smoke impacts include, particulate matter emissions, mixing height, and transport winds. Emissions are influenced by several factors including fuel type, fuel loading, amount of fuel consumed, and smoldering.

Table 3. PM10 Emissions for Blackwater NWR Fuel Models.

Fuel Model	PM10 (lbs/acre)
1	**11**
3	**68**
5	**72**
6	**149**
8	**145**
9	**181**
11	**127**

Burns are planned during periods of sufficient mixing height and with transport winds that will carry smoke away from communities, residences, highways, and airports. If smoke across a highway cannot be avoided, traffic control and smoke monitors are used to prevent traffic problems. Woodland burns are conducted in such a manner that temperature, relative humidity, fuel moistures and mop-up operations combine to reduce smoldering. Smoldering is usually not a problem in marsh and agricultural burns.

Wildfires that occur during conditions outside of prescription parameters will be more severe events and will likely have greater fuel consumption and in turn more particulate matter emissions. Also, wind direction may

carry smoke directly toward sensitive areas.

D. Soils -- Prescription burns are conducted when soil moisture is between 100-300%. Therefore, fire penetration into the soil and consumption of organic soils is not a problem. In the marsh, heat may penetrate a few inches below the surface but the steam layer formed from saturated soils helps insulate soil and plant roots and rhizomes. Generally, the marsh surface is flooded and/or frozen which prevents any fire from entering the subsurface layer. In woodland burns, the duff layer may be charred, but organic soils are not burned. In grassland burns, soil involvement does not occur.

Wildfires, particularly in the woodland setting, often occur at times when soil moisture is low and therefore complete consumption of organic layer and exposure of mineral soils can result. This not only causes negative long term effects for the vegetative community but increases erosion, which in turn effects water quality.

5. Refuge Fire Management Objectives

A. Ensure public and firefighter safety while protecting property and natural resource values from wildfire.

B. Provide a level of wildland fire management that will result in the least cost plus net value change (cost efficient level) commensurate with resource management objectives and constraints.

1. Reduce wildfire impacts to all resource management activities. Reduce the threats associated with accumulations of hazardous fuel loads in marsh and woodland habitats, and with trespass and arson fires in the intermingled Federal/State/private lands and along the wildland/rural interface.
2. Assure no disruption or adverse impacts on transportation/utility corridors occurs from wildland fires.
3. Protect valuable resources of international, regional, and local significance from wildland fires.
4. Maintain cooperative associations with State and local fire management agencies and organizations for the purposes of resource protection and management.

C. Use fire to accomplish resource management objectives.

1. Provide, maintain, enhance, and protect habitats for State and Federal endangered and threatened species, and species of special concern.
2. Provide, maintain, enhance, and protect feeding, resting, nesting, and brood habitat that meets the requirements of migratory waterfowl, other migratory birds, and resident wildlife.
3. Maintain health and vigor of marsh vegetation, maintain current marshland acreage and species composition, and reduce brush invasion into marshland.
4. Facilitate the control of resident and exotic furbearers.
5. Encourage the regeneration and growth of loblolly pine stands by reducing understory competition.
6. Increase habitat diversity in refuge woodlands.
7. Provide diverse and abundant food crops in agricultural and moist soil management units to meet the nutritional requirements of various wildlife species.
8. Control Phragmites expansion.

D. Implement a process for the monitoring and analysis of the effects of fire management actions and use of the information derived in an adaptive management approach.

1. Design and implement an evaluation of the effects of prescribed fire rotation interval on major vegetative communities and their associated wildlife as recommended by the 1995 Fire Review Panel in their 1996 report: "Technical Review of Fire Management in the Blackwater National Wildlife Refuge and Adjacent Wetland Management Areas".
2. Serve as an outdoor laboratory for fire effects research.
3. Ensure accurate reporting and tracking of wildfire incidents and their impacts.

E. Demonstrate and educate the public about the role and benefits of wildland fire protection and prescribed fire use in natural resource management.

F. Maintain current ecosystem diversity within the landscape context, and contribute to the recovery and restoration of the Chesapeake Bay ecosystem.

G. Comply with State Air Quality Implementation Plans to protect public health and the environment.