Fire Ecology in Shenandoah National Park

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INTRODUCTION

SHENANDOAH National Park was established by an Act of Congress in 1935 to preserve a representative segment of the scenic Central Appalachian Mountains for the future benefit and enjoyment of the American people. The park is unique among most in the National Park System because of its very origin. Prior to park creation the mountainous region was practically decimated of all natural vegetation and animal life. Likewise the area in the early 1930's was "home" for over 3,000 mountain folk.

From almost total degradation then, parkscape protection over a 35-year period has permitted natural and human scars to heal, so that today the park exists in a more or less natural state.

The chief scientific interest in the park is the ecological changes that have taken place since its establishment. Shenandoah National Park presents a rare opportunity for ecologists to study the dynamic processes of natural succession from extensive clearings to dense forests. The primary objective of this report is to indicate the significant role that fire has played in the ecological changes to the parkscape in time and space.

Field data were collected during nine summers of residence in Shenandoah National Park from 1963 through 1971. Total field time approximated 28 months. Additional information was acquired

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from park personnel, former park inhabitants, and Alderman Library at the University of Virginia, Charlottesville. Field techniques included establishing study plots in clearings and forests, mapping and photographing plant communities, and recording daily phenology occurrences.

THE STUDY AREA

From Front Royal to Waynesboro, Virginia, the Blue Ridge Mountains consist primarily of a single high ridge with perpendicular spurs between two adjoining lowlands—the wavelike foothills of the Piedmont Plateau to the east and the Great Valley of Virginia to the west (Fig. 1). The range trends in a northeast to southwest direction and nowhere exceeds 15 miles in width (Connelly 1968). In its narrower parts, as between Afton and Waynesboro, it is a single ridge that stands about 2,000 feet above the Piedmont and 1,200 feet above the Great Valley (Wright 1927).

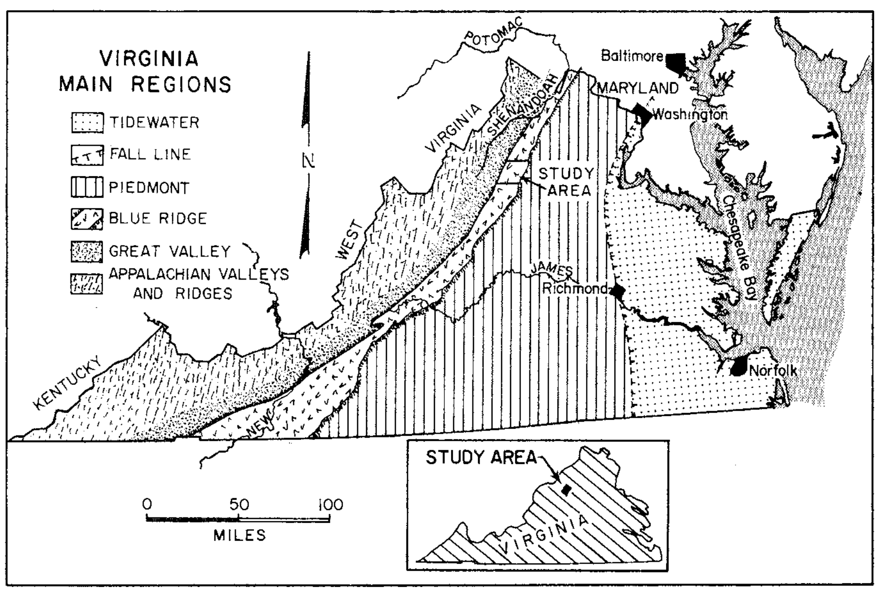

Fig. 1. Main regions of Virginia. Adapted from J. Gottmann, *Virginia at Mid-Century* (New York: Henry Holt & Co., 1955).

Overall, the main ridge has an average altitude of 3,000 feet above mean sea level. Its mid-section forms a slight arch, the crest of which averages 3,400 feet. The highest peaks in the study area, Hawksbill Mountain (4,049 feet) and Stony Man Mountain (4,010 feet), are in this part of the range (Anderson 1935).

The rounded Blue Ridge Mountains record more than a billion years of earth history. They consist basically of very old crystalline rocks (pre-Cambrian granites, granodiorites, and schists), which occur as uplands, and younger sedimentary and metamorphic rocks (Cambrian limestones, shales, and quartzites), which form low hills and valleys in a narrow zone on the Shenandoah Valley side. Catoctin greenstone schists, formerly massive flows of metabasalt (Keith 1894), cap most of the summits and ridges of the Blue Ridge and are well exposed in gaps and highway cuts between Rockfish Gap (Waynesboro) and Chester Gap (Front Royal). The essentially continuous exposure along the western side of the ridge has allowed weathering and erosion to break through to the underlying intrusives in the vicinity of Hughes River and Thornton Gaps. On the eastern side of the ridge outcrops are generally confined to the mountain summits.

The main ridge forms a backbone divide between the headwaters of streams that follow an easterly course over the Piedmont and Coastal Plain to the Atlantic Ocean, and those that flow westward into the Shenandoah River to reach, eventually, the Atlantic via the Potomac River. The drainage descent is precipitous on both sides of the main ridge, resulting in the formation of short canyons, numerous waterfalls, cascades, and rapids. In fact, topography is rugged throughout the region, with less than 10 percent of the surface area having a slope less than 10 percent.

The Blue Ridge, with numerous streams, cascades, springs, waterfalls, and dense forests, superbly illustrates a humid mid-latitude landscape. The mountains have a variable climate due to their length, relief variance, and daily to monthly changes in atmospheric conditions. Seldom does the entire range experience the same daily atmospheric phenomena. Further, seasons contrast considerably more in the amounts and kinds of precipitation, in the number of sunny and cloudy days, and in the extent and intensity of heat and cold.

Weather stations at Luray (5 miles east of town at Shenandoah National Park Headquarters, elevation 1,000 feet) and at Big Meadows (10 miles southeast of Luray, elevation 3,500 feet) give some indications of general climatic conditions in the study area. Data collected at these stations are available for a 35-year period (1935–1969) and have been analyzed in Table 1.

Soil is one of the most obvious factors which determines the extent of plants and animals in the Blue Ridge, yet little scientific attention has been given to it. Perhaps the reason for this is that most of the study area is under National Park Service control and is primarily considered to be a recreational zone with few permanent inhabitants. The result, nonetheless, is the lack of a detailed soil survey and soil map of the study area.

Basically there are two soil orders or subdivisions in the Blue Ridge Mountains (Marschner 1959): 1) zonal soils, which formed under stable conditions through the prolonged action of climate and vegetation, and 2) azonal soils, which have no or poorly developed characteristics, either because they have had insufficient time to develop, or because they are on slopes too steep to allow profile development (Strahler 1960). Blue Ridge zonal soils are the gray-brown podzols of the great soil groups. They are best represented in the study area by three types: 1) Porters Loam, 2) Porters Stony Loam, and 3) Mixed Silty, Sandy, and Stony Loams. Together these three soil types constitute about 90 percent of the local soils and have developed under forest cover mainly of hardwoods, although conditions were not favorable for the accumulation of vegetable matter. Two azonal soils, alluvium and stony colluvium, make up the remainder of area soils and have formed in the hollows and coves. Under normal conditions these soils are well-drained and higher in fertility and productivity than stony loam soils.

NATURAL VEGETATION

The term "natural vegetation" is sometimes thought to refer to the original vegetative types, which in the Blue Ridge Mountains belong to pre-Columbian times. However, very little of the present

TABLE 1. CLIMATIC DATA FOR TWO WEATHER STATIONS IN THE BLUE RIDGE: 1935–1969

Station	Monthly Means												Annual Totals
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Big Meadows													
Temp.	28.8	30.0	36.6	48.9	56.8	63.4	66.7	65.4	59.8	51.4	39.6	30.0	48.1° F.
Prec.	3.37	3.15	3.72	4.14	4.18	4.36	4.58	5.63	4.86	4.68	4.09	3.34	49.05 in.
Luray													
Temp.	34.4	36.3	43.3	53.8	60.9	70.0	73.2	72.2	65.7	56.3	45.6	35.4	56.7° F.
Prec.	2.65	2.40	3.19	3.11	3.66	3.46	3.86	4.59	3.37	3.36	2.89	2.55	38.72 in.

SOURCE: U. S. Department of Commerce, Weather Bureau, *Climatological Data on Virginia, Annual and Monthly Summaries* (Washington, D. C.: Government Printing Office, 1935–1969).

mountain vegetative cover (about 1 percent) belongs to these types (Berg and Moore 1941). Profound changes in most of the original plant associations were caused by natural events, such as lightning-caused fires and flash floods, and by aboriginal and European activities, such as firing the land, cutting of trees, plowing, and grazing. Natural vegetation as used in this study, therefore, implies all vegetative types that grow without cultivation and include the few remnants of the native vegetation still existing in the Blue Ridge Mountains.

The key to an understanding of the original Blue Ridge vegetation as a whole, and the spatial relations of its integral parts, is obviously to be sought in those areas where ancient vegetative types have survived, despite dire natural and human events in the past (Braun 1964). In some parts of the Blue Ridge, like Shenandoah National Park, landscapes have made a complete cycle from native vegetation, through almost total denudation, to natural environmental renewal (Wilhelm 1968). It is important to examine in this report each one of these stages of change. Emphasis is placed on the higher forms of vegetation, the forests, because of their ecological dominance in the landscape.

The Native Blue Ridge Forest

The Blue Ridge Mountains have been occupied by the deciduous or summer green forest formation certainly for thousands of years (Braun 1964). There have been repeated changes during its long period of existence in land relief, climate, water supply, and soils. Each change, whether catastrophic and widespread or minor and local, has exerted a profound influence on the nature and extent of the forest. The present Blue Ridge deciduous forest with its various segregated subtypes is due, therefore, not only to more recent environmental conditions and to human interferences, but also to the changing history of former environments.

Records of the nature and appearance of the Blue Ridge native forest are meager and fragmentary. They may serve, at best, to substantiate the evidence afforded by the forest remnants of today, but they do not enable one to visualize the original conditions in their entirety. A perusal of botanical literature on the forests of the Southern Highlands finds written materials largely confined to the Great Smoky Mountains (Stupka 1964). Perhaps this is to be expected, for the Great Smoky region is not only a zone of great antiquity, high elevations (several summits tower above 6,000 feet), and abundant precipitation (80 in/year), but also it has been a refuge for many plants that were unable to find suitable habitats outside the mountains during periods of climatic and topographic change (Farb 1963). Many endemic plants are relics of the Tertiary flora, of which a considerable number have their closest relatives in eastern Asia (Cain 1943). Many other plants have allies in western Europe.

Today the Great Smoky Mountains are the home of more than 130 tree species (Stupka 1960), or about 45 species more than are found in all of western Europe. Nearly 20 of these species reach record proportions (Baldwin 1948). Finally, there are about 1,400 kinds of flowering plants, 350 species of mosses and relatives, and about 2,000 species of fungi. This outstanding wealth of plant life makes the Great Smoky Mountains the unexcelled center of natural vegetation in the conterminous United States. The Blue Ridge Mountains at least approach this luxuriance in natural vegetation to some degree.

Presently, about 40 percent of the Great Smoky Mountains National Park is occupied by virgin forests. Forest types include: oak-hickory, cove hardwoods, oak-pine, northern hardwoods, and spruce-fir. These native forest communities are significant because they represent a microcosm of most of the possible environmental aspects of the entire Appalachian chain in one confined area. Thus I was aided in reconstructing the appearance of the Blue Ridge forest by comparing the empirical evidence gathered in the virgin forests of the Smokies with the original forest remnants in the study area. Comparative data must be used with caution, however, for environmental conditions are not identical in both locations.

The Blue Ridge flora lacks the luxuriance and variety which distinguishes the Great Smoky Mountains 300 miles to the south. The less varied topography, lower relief, less precipitation, and the different geologic history of the study area are the major factors responsible for this contrast. The Blue Ridge area was greatly reduced at the time of development of the Schooley Peneplain; only isolated knobs and low swells rose above the general level. Nevertheless, preliminary check lists of the flora of Shenandoah National Park include 269 fungi, 224 bryophytes, 890 vascular plants, and 160 woody plants, of which 100 species are trees (Fosberg and Walker 1941, 1943, 1948, 1955).

An ecological view of the Blue Ridge between 1670 and 1716 A.D. (Cumming 1958; Somerville 1965) shows that the forest was intact except for scattered clearings along the main ridge, in isolated coves, and at mouths of some hollows (Shelford 1963). The forest formation was dominated by oaks and American chestnut, the largest stands occurring on slopes between 1,500–2,500 feet elevation. Quality trees of many species grew in the hollows and coves; poorer specimens generally were found on the high slopes, ridges, and in gaps (Hough 1877). In fact, it seems that much of the old forest was of poor form, small size, and low quality (Hack and Goodlett 1960).

The White Oak Canyon District, on the eastern slope of the Blue Ridge Mountains in Shenandoah National Park, is the most extensive area of undisturbed forest in the study area. A dozen or so large white oak (*Quercus alba*), red oak (*Q. rubra*), and chestnut oak (*Q. prinus*) trees are dispersed over the canyon district, growing in locales of difficult access. At least half of these trees are estimated to be approximately 300 years old and have diameters averaging 3½ feet at breast height (Fig. 2). "Limberlost," a section of the headwaters of the canyon, harbors rows of sturdy eastern hemlock (*Tsuga canadensis*) trees estimated to be 400 years old and over 4 feet in diameter at breast height (Fig. 3). Occasionally a dead standing American chestnut of considerable size attests to a forest of former grandeur (Fig. 4).

There is a close relationship among geology, relief, climate, adjustment of soils, and natural vegetation. In large measure forest morphology is the product of a long period of interaction between botanical and geomorphic processes. Trees grow larger and taller

FIG. 2. A white oak (*Quercus alba*) estimated to be over 250 years old near Big Meadows in Shenandoah National Park. Note the broad lateral branches. Photo taken by the author in May, 1966.

in hollow and cove bottom lands, for example, than on upland ridges due to more favorable slope, finer textured soils, and sufficient moisture.

With these relationships in mind, three forest types were commonly distributed prior to European settlement of the Blue Ridge:

1) The Hollow-Cove Hardwood Forest Type, defined by the presence of basswood (*Tilia americana*), tulip tree (*Liriodendron tulipifera*), yellow birch (*Betula lutea*), sugar maple (*Acer saccharum*), black gum (*Nyssa sylvatica*), white ash (*Fraxinus americana*), and American elm (*Ulmus americana*). None of these species is predominant. Associates include black birch (*Betula lenta*), red oak, white oak, chestnut oak, American chestnut (*Castanea dentata*), sycamore (*Platanus occidentalis*), and magnolia (*Magnolia tripetala*). Two conifer species, the white pine (*Pinus strobus*) and eastern hemlock, are often found in association with the hardwood trees.

2) The Yellow Pine Forest Type, defined by the presence of pitch

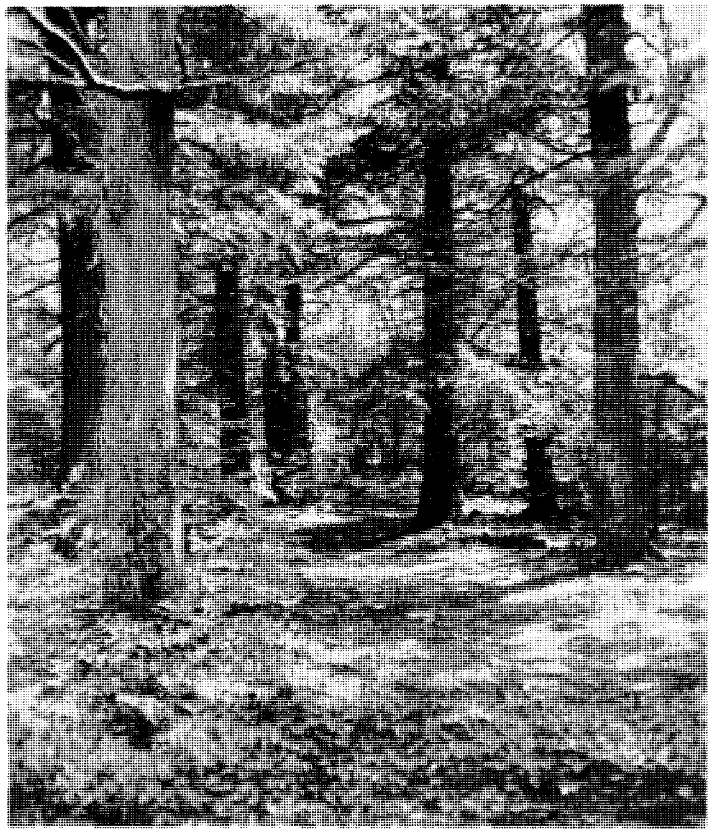

FIG. 3. Several eastern hemlocks (*Tsuga canadensis*) in Limberlost, Shenandoah National Park, estimated to be 400 years old. Photo courtesy of the National Park Service, 1956.

pine (*Pinus rigida*) and Virginia pine (*Pinus virginiana*) and the absence of most or all species of the hollow-cove hardwood forest. The table-mountain pine (*Pinus pungens*) is an infrequent associate member of this forest type in the extreme southwestern part of the study area.

3) The Oak-American Chestnut Forest Type, defined by the presence of dominant species like the red, chestnut, and white oaks and the American chestnut, is the most extensive of the three forest types. In many areas, the American chestnut was the single, dominant species, often occurring in pure stands. Probably at least 15 percent of the entire Blue Ridge climax forest was occupied by American chestnut, and this estimate may be low. The chestnut has been eliminated by blight, thus the oak-chestnut forest no longer occurs in its original condition. The name is retained, however, because it is

FIG. 4. A dead standing American chestnut (*Castanea dentata*) tree near Big Meadows, Shenandoah National Park. Photo taken by the author in June, 1965.

impossible as yet to predict the final outcome of the partial secondary successions in progress. Originally this forest type had a wide and varied distribution. The range of elevation was from about 1,200 feet to about 4,000 feet. The chestnut comprised about 35 percent of the forest type on drier ridges and on south- and west-facing slopes. Oaks and chestnut together comprised about 85 percent of the forest type composition. Variations in composition of the oak-chestnut forest occurred as transitional communities related to the moister and usually lower hollow-cove hardwood forest, or as transitional communities related to the drier and often higher yellow pine forest. Species associated with the drier transitional communities included pitch and Virginia pines, pignut (*Carya glabra*), shagbark (*C. ovata*), bitternut (*C. cordiformis*), and mockernut (*C. tomentosa*) hickories. Tulip trees and hemlocks mingled with the oaks and American chestnut on north and east slopes under moister conditions.

Today the understory plant life differs considerably among the three forest types. The hollow-cove hardwood forest lacks the brushy ground cover which is typical of the yellow pine and former oak-chestnut forests. Instead, the community develops a rich herb layer. Black cohosh (*Cimicifuga racemosa*), trillium (*Trillium* sp.), wood-nettle (*Laportea canadensis*), and several species of orchids are among the more common showy species. On the other hand, the yellow pine and oak forests have brushy and dense undergrowth. Most of the woody plants are members of the heath family (Ericaceae) and generally possess the shrubby form characteristic of the family. Of these heath plants, mountain laurel (*Kalmia latifolia*), flame azalea (*Rhododendron calendulaceum*), and pink azalea (*R. roseum*) are the most widespread. Dense shrubby heaths are more characteristic components of the ground cover in yellow pine forests than former oak-chestnut stands. Where the latter forest contains some of the species of the hollow-cove hardwood forest, the ericaceous layer is absent, and a herbaceous tier, resembling that of the hollow-cove hardwood community, takes its place.

Occasional hemlock stands are scattered through the Blue Ridge along streams and lower slopes up to an altitude of 4,000 feet. Apparently the hemlock prefers two types of habitats: the cool, moist hollows and coves at lower elevations mostly on the east slope, and north slopes at higher elevations where permanent springs and streams exist. In places the undergrowth is strongly dominated by mountain laurel and azaleas. The herb layer is practically nonexistent underneath these shrubs, but a rich assortment of colorful fungi does occur after the late summer thundershowers.

The distribution of species that defines the three major forest types shows a high degree of coincidence with the distribution of other components of the landscape that can be readily recognized and described. The relation between forest types and topography, slope, and soil types is particularly evident.

The hollow-cove hardwood forest occupies the alluvial-colluvial flood plains of the larger valleys, extends as a thin line up the bottoms of the major tributary valleys, and enlarges into a tear-shaped area at the heads of most hollows. This forest type also extends much farther up the side slopes and occupies more extensively those hollows on the northeast-facing slopes than on the southwest-facing slopes. As far as I could tell from field observation, these northeast-facing forests were in a transitional area of colluvial and Porters loamy soils. A few flat basin coves, underlain by limestone and shale, occur in the southwest corner of the study area. Mixed silty and sandy loam soils produce a rich sample of mixed hardwoods. Luxuriant specimens of basswood, tulip tree, magnolia, and yellow birch exist near the headwaters of the coves, but gradually give way to species adaptable to less soil moisture near the mouths of coves: oaks, hickories, pines, and red cedar (*Juniperus virginiana*). In general, the hollow-cove hardwood forest type is restricted to valleys and other slope surfaces that are concave outward.

The yellow pine forest, on the other hand, is generally restricted to ridges, high and mid-slopes that are convex away from the mountain. This forest type is extensive on the dry slopes and outlier ridges on the Great Valley side. Underlain mostly by resistant quartzite parent material, the thin, stony, loam soils still manage to support extensive stands of pitch and Virginia pine.

The oak-American chestnut forest type generally grows on straight to gently sloping profiles. Supported by Porters loam and stony loam soils, the type occupies the intermediately dry to moist sites that are underlain by granite, granodiorites, and greenstone schists. It is readily noted that many of these relations are largely controlled by one common environmental factor, the distribution of ground moisture.

The ridges and hollows that characterize the slopes largely determine the distribution of runoff. Thus many areas in which runoff is concentrated in large amounts support hollow-cove hardwood forest;

areas in which runoff is dispersed support yellow pine forest; and many areas in which runoff is intermediate support oak-American chestnut forest. The total amount of water at any level of moisture content is greater in hollows than on side slopes and ridges because of the greater volume of soil that becomes saturated (Hack and Goodlett 1960).

Moisture during the growing season is of primary importance. Rainfall occurring during the dormant season is critical only when it falls in such minor amounts that the growing season begins with a moisture deficiency.

Differences between forest sites are related also to differences in exposure. For example, northeast-facing slopes usually support areas of hollow-cove hardwood forest. Probably evaporation and transpiration rates are reduced on this side, while loss of soil moisture by these processes is pronounced on south- and west-facing slopes. The prevailing westerly winds increase evaporation and transpiration rates on these slopes, and air and surface temperatures are higher because these sides receive the direct rays of the sun during the warmest parts of the day. The vegetative effect is that the hollow-cove hardwood forest type is usually absent from the south- and west-facing slopes.

The high central ridge has significant effect upon the local climate and the distribution of tree species. Vegetative differences are probably caused by an orographic effect on the distribution of precipitation in the form of local thundershowers, lower temperatures accompanied by reduced evaporation and transpiration rates, more snow, sleet, and ice, shorter growing seasons, and a greater instability in the soil mantle produced by frost.

Finally, because of the scarcity of data concerning the Blue Ridge forests of the distant past, detailed speculation about the further description and changes in the vegetation is futile. The relationships discussed in this report provide a minimum basis for extrapolation to some unknown but not too distant time in the past. Not only is fossil material lacking, but also proof that the physical requirements of plants and ecological relationships depicted herein were the same then as they are now. The guide followed in this discourse has been simply that they were similar.

LANDSCAPE CHANGES AND FIRE

Mountain clearings atop the Blue Ridge represent a sharp contrast to the overall forest landscape. Probably the most celebrated clearing is Big Meadows in the central district of Shenandoah National Park.

It is difficult to state how long Big Meadows has been in existence and under what circumstances it developed. Probably its origin can be traced back to one, or a combination, of three causes: 1) a natural glade or bog formed by edaphic-topographic factors; 2) a forest opening created by natural lightning strikes; and 3) a forest clearing caused by Indian burning and girdling of trees.

Some authorities have stated that at least a few, small, grassy, marsh-like depressions developed in the Appalachians under natural circumstances (Clarkson 1966). These treeless areas were apparently of indefinite duration, and in that respect resemble the grass balds of the Great Smoky region (Camp 1931). The origin and permanence of grass balds are beyond this study, but it should be pointed out that grass balds and Blue Ridge clearings have similar settings. Both plant communities are found on high ridges under extreme exposure. Both are in contact with high elevation types of deciduous forest. And both plant communities are dominated by grasses, sedges, and flowering herbs.

But there are also significant differences between the two grassy types. Grass balds are much higher in elevation (usually above 5,000 feet) than the Blue Ridge clearings. Big Meadows, for example, is situated at 3,560 feet. Then, too, grass balds encounter harsher climatic conditions than do the clearings; stronger winds, colder temperatures the year round, more snow, and a shorter growing season are typical characteristics of grass bald areas. Finally, grass balds are found on steeper slopes, usually clinging to mountain summits, and they come in contact with altogether different species of deciduous trees than do the Blue Ridge clearings. Woody plants either do not invade the grass balds or they are doing so at a very slow rate. Blue Ridge clearings, on the other hand, revert back quite rapidly to forest land.

Various theories as to the origin of grass balds have been proposed, including windfalls, landslides, fires (lightning and man-caused), grazing, climate, and edaphic-topographic control (Wells 1956; Billings and Mark 1957). None of these theories answer all of the questions about the origin and permanence of these plant communities. At any rate, research is continuing at present (Gersmehl 1971).

It is readily seen that Big Meadows is a wet clearing, even in the driest season, and illustrates a poorly drained segment of land (Fig. 5) where the vegetation can be classified as a grass-sedge meadow

FIG. 5. The wet center of Big Meadows, Shenandoah National Park, in May. Photo taken by the author in 1966.

or fen. The meadow actually is in the shape of a shallow bowl with radial drainage pointing to the center (Fig. 6). An inch or two of standing water is apparent through most of the year, but before mid-July the center is usually reduced to a damp grassy bog (Fig. 7). A ring of American hazelnut (*Corylus americana*) and hawthorn (*Crataegus* sp.), averaging 5 feet in height, encircles the boggy center (Fig. 8). Around the upper perimeter of the meadow, perhaps an average distance of 1,500 feet away from the meadow center, are several pitch, Virginia, and white pines, black locust (*Robinia pseu-*

FIG. 6. View east across Big Meadows showing sunken center. Photo taken by the author in June, 1968.

FIG. 7. Bracken fern growing in Big Meadows. Photo taken by the author in June, 1965.

doacacia), sassafras (*Sassafras albidum*), and red oak. All of these species are above 6 feet in height and all (including the hawthorns and hazelnuts) have invaded the meadow since the creation of Shenandoah National Park in 1935 (Fig. 9). Although pine and oak trees have invaded the better-drained parts of the meadow, and 10 test pits 3 feet deep by 3 feet wide around the meadow's perimeter in 1964 uncovered old tree trunks and root systems, no trunks were

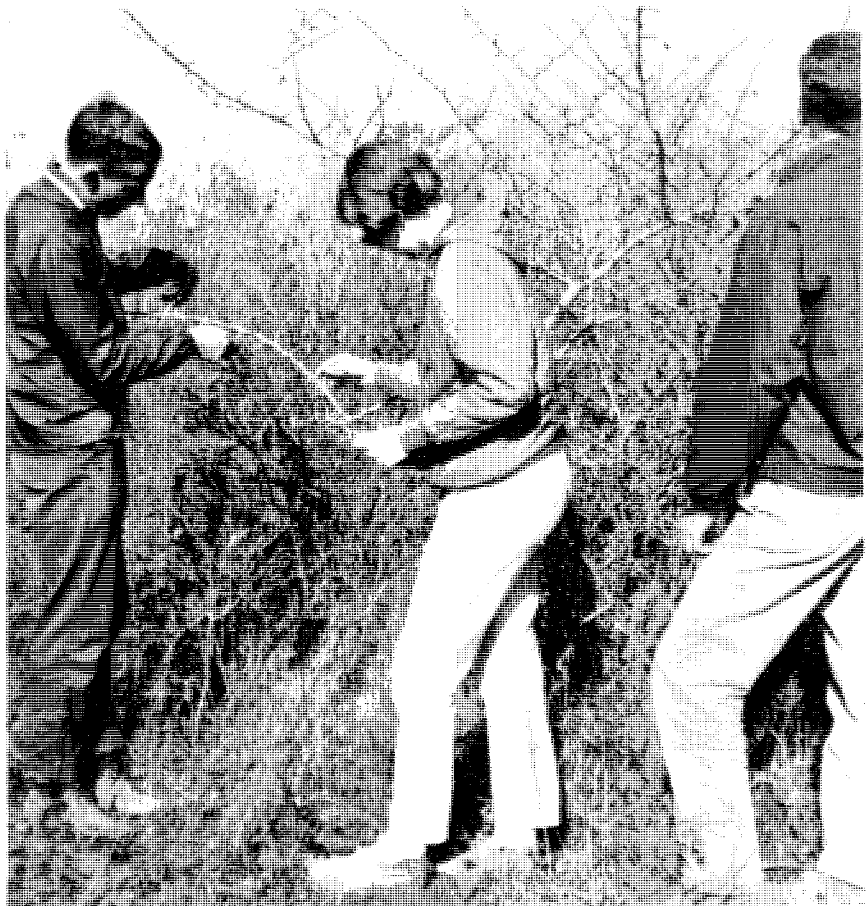

FIG. 8. A grove of American hazelnut (*Corylus americana*) and hawthorn (*Crataegus* sp.) in the midst of Big Meadows. Photo taken by the author in March, 1968.

recorded in the central depression where in some years water stands most of the time.

It is probable that the central depression, an area approximately 200 yards long by 200 yards wide, was always a marsh during humid times and a wet glade during periods of drought. If trees grew in the meadow prior to Shenandoah National Park, they were not commented upon. Besides, photographs taken by park personnel in the

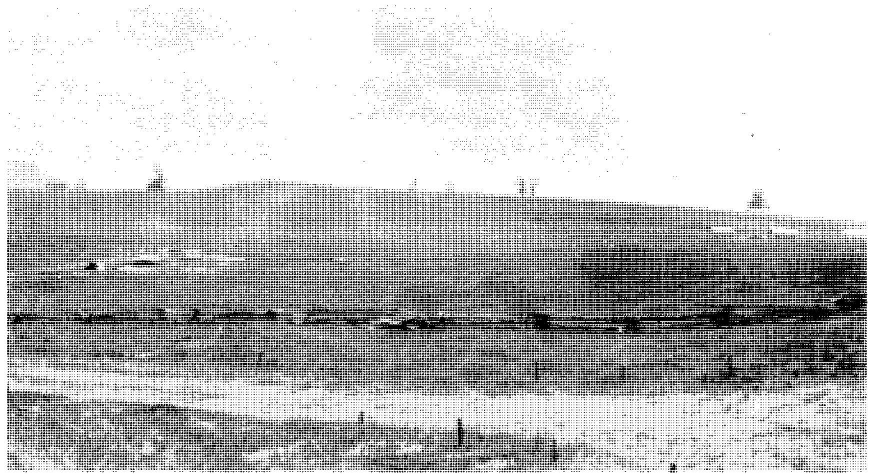

FIG. 9. A view eastward across Big Meadows in 1935. Photo courtesy of the National Park Service.

1920's of Big Meadows show only a vast clearing. It is very likely that trees have not grown in the meadow for centuries of time. This fact is verified by early settlers who were surprised to discover a broad open tract, perhaps 4,000 acres or more in size, denuded of trees in an otherwise forest environment (Strickler 1952). The initial pioneers called the clearing "Great Meadow," "Big Clearing," or "The Barrens." The latter term became standardized in the mountain folk vocabulary for an expansive mountain clearing devoid of trees (Judy 1936–37). Pasture Fence, in the south district of the park, was the only other barren known at the time of pioneer settlement. Finally, former park residents, who lived in the vicinity of Big Meadows and Pasture Fence and were descendants of initial settlers, verify that both areas were treeless, grassy meadows for generations.

There is little doubt that so long as there have been forests in the Blue Ridge, fire has played a vital role in the natural scheme of things. To date, however, emphasis has been placed on man-caused fires as being responsible for determining the vegetative cover in the Blue

Ridge Mountains. It is suggested that lightning should not be overlooked as a possible cause for the origin of Big Meadows and other ridge clearings (Shelford 1963).

Rather sound meteorological evidence shows that lightning is a basic cause of fires in the Blue Ridge. Lightning is produced by two types of weather patterns: the line or squall type of thunderstorm, and the convectional thunderstorm. The data collected by the National Park Service and Forest Service on lightning-caused fires show that fire potential is much greater than expected from thunderstorm-day data. This is particularly true for the high ridge zone of the study area where most lightning storms occur.

Recent data collected by the World Meteorological Organization show that Virginia has between 40 and 60 thunderstorm days/year. Lightning is of such frequency and magnitude in the Blue Ridge that there are not many localities, if any, that at some time or other have not been subjected to fires caused by lightning. There is no reason to doubt that Shenandoah National Park records of lightning-caused fires over a 35-year period (1933–1968) differ greatly from centuries ago. These records indicate that there is an average of 1.5 lightning-caused fires per year within the study area. Such fires constitute about 15 to 16 percent of all fires recorded over the 35-year period and characteristically develop in the summer months in association with convectional and frontal storms. Certainly these fires have occurred at frequent enough intervals to have had some lasting effect on the Blue Ridge landscape prior to the coming of man.

Today rigid fire control prevents the natural processes of lightning-caused fires to operate. Yet lightning strikes have some ecological impact on the landscape. Each year hundreds of forest trees are struck by lightning. Field observations since 1956 indicate that most of these trees are the tallest and most mature specimens in the forest. Limberlost, an area containing approximately 60 stately 400-year old hemlock trees, has been hit consistently over the years. Nine giant hemlocks have been struck by lightning in the past 15 years. At this rate the remaining tall trees will be destroyed in less than a century (Fig. 10).

Few estimates have been made as to the number of lightning

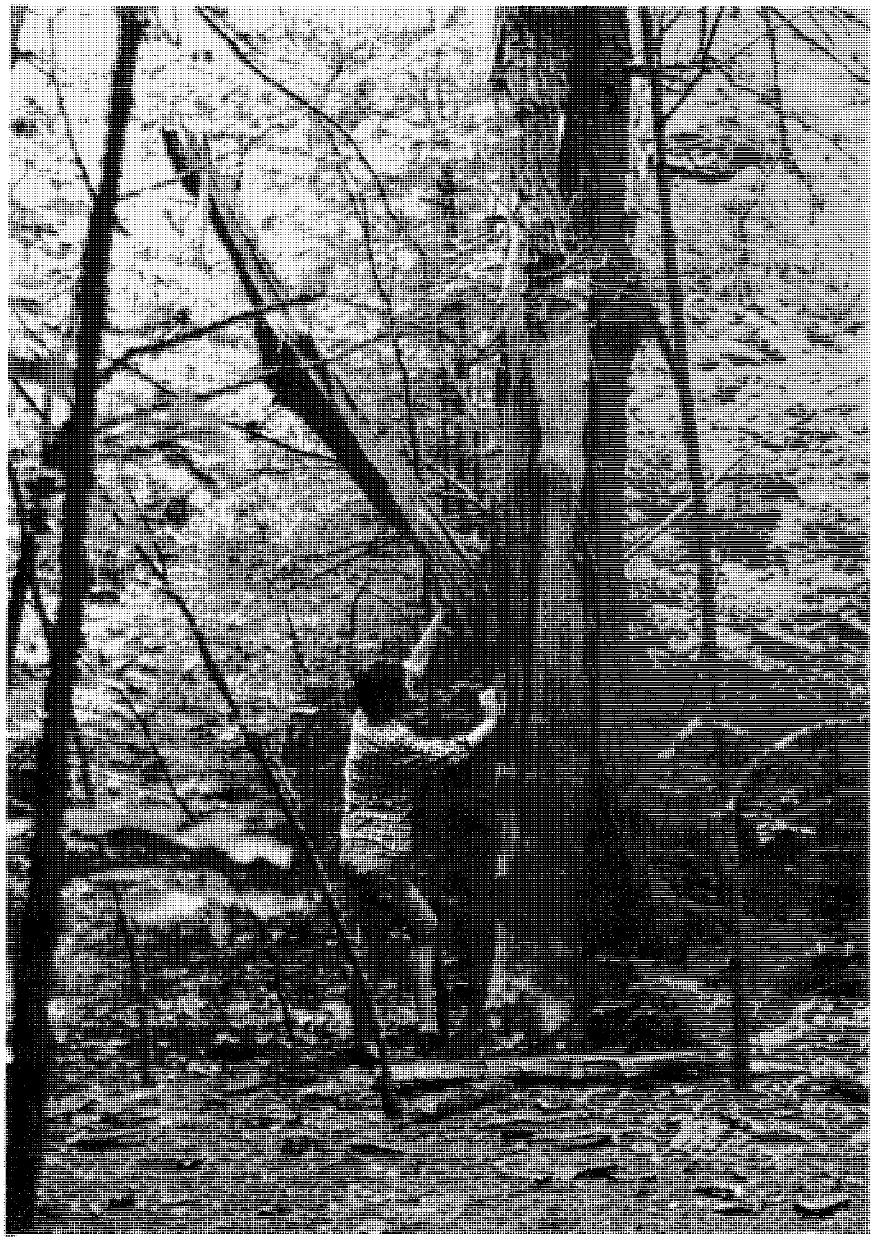

Fig. 10. A lightning-struck eastern hemlock tree near Limberlost, Shenandoah National Park. Photo taken by the author in May, 1964.

strikes that occur on a regular basis. One investigator in 1966 estimated that over 2,700 lightning thunderstorms passed over a large segment of the United States in an hour period (Komarek 1968). This represented only one frontal activity and these fronts sweep the country on an average of once every 7 to 10 days in the summer.

Under these conditions, one squall line can have serious consequences on any particular area of forest land by causing widespread lightning fires. All too familiar to park and forest personnel is the weather pattern that occurs toward the end of a dry spell or drought. Clouds and lightning storms come with great frequency, with little precipitation ever reaching the ground. Most dry spells fall between June and October, thus lightning-caused fires associated with these storms are summer fires.

Frontal movements through the Appalachians are common, causing lightning fires to move with the fronts. Many national forests and parks are located all along the mountain chain. These are usually regions of high precipitation, but even here dry spells occur in certain years, making the dry forests subject to more common lightning without precipitation. The dominant hardwood forest, less apt to be set afire because of less combustible fuel, is particularly susceptible in dry spells.

Summer fires have a much more profound effect on the control of woody growth than winter fires. Summer fires, even if occurring infrequently, could create, maintain, and enlarge the grassy tracts alluded to without too much difficulty, provided environmental conditions were suitable. The leaves of the hardwoods become closely packed to the ground and will only burn under very dry conditions, so that circumstances for fire to spread must be severe. However, there are tree species in the Blue Ridge that are adjusted to fire. White, pitch, and Virginia pine stands originated on burnt areas, for the species required some mineral soil on which to germinate and grow. Even with considerable lightning in the Blue Ridge, the rainfall patterns are such as to prohibit extensive fires except during the infrequent droughts or dry spells. Therefore, Big Meadows and similar clearings may have originated from lightning-caused fires, but even if they had, their expanse seems to have been created by man.

MAN AND FIRE

When aboriginal man first penetrated the Blue Ridge is still unknown, but certainly that event took place many thousands of years ago. Although the archeological literature is quite extensive for the eastern United States as a whole, the number of reports dealing with archeological materials in the Blue Ridge Mountains of Virginia is extremely limited. One preceramic quartzite site was examined in Jarman Gap, 3 miles east of Dooms, Augusta County, Virginia, some years ago (Holland 1960). Fifteen points and blades, 221 chips, and one sherd were collected and deposited with Shenandoah National Park. The materials were said to belong to the Early Archaic period of aboriginal occupation. Only one other site, a rockshelter on the eastern side of the mountains in Greene County, has been excavated within the study area. It seems that the shelter was utilized as a seasonal hunting camp by a band of people belonging to the more recent Woodland period (Holland and O'Ryan 1964).

Two archeological reports from a mountainous district of the Blue Ridge some 75 air miles south of the study area, called Peaks of Otter, and recent findings from the Valley of Virginia and the Piedmont adjoining the study area indicate a period of aboriginal history stretching over thousands of years. Unfortunately, it is impossible without archeological proof to state that the culture history revealed by these findings would be the same or similar to that of the study area. It can be assumed only that the similar environmental conditions between the Peaks of Otter district and parts of the study area (e.g., Big Meadows), the long occupance of the former mountainous site, bountiful natural resources, and the close proximity of ancient, widespread, lowland cultures are facts that point to this probability. Support for such an assumption rests primarily upon the remarkably similar cultural artifacts uncovered at the Peaks of Otter, in the Valley of Virginia, and on the Piedmont.

All the archeological evidence shows that the Peaks of Otter district was the scene of repeated prehistoric Indian visits occurring over a time span of at least 9,600 years (8000 B.C.-1600 A.D.). Perhaps small bands of hunters and gatherers used the area as one of several seasonal camps in an annual cycle, which saw the people moving from the lowlands to the mountains to take advantage of the changing seasons, abundant vegetative resources, and mobile big game. The many hearths uncovered at the site likewise attest to the importance of fire, and suggest the possibility that early man could have created and extended forest clearings, like Big Meadows, through the agency of fire nearly 10,000 years ago. Such a suggestion has been proposed before by Ahlgren and Ahlgren (1960), Cooper (1961), and Thompson and Smith (1970) among others.

Evidence points to the fact that early Indians were responsible, at least in part, for clearings like Big Meadows through intentional burning and girdling of trees. Contemporary writers have underestimated the total effect of fires set by the Indians. In fact, one need not delve very deeply into the historic records of Shenandoah to realize that the Indians had altered the forest cover to an extent far out of proportion to their numbers. The most common openings, called "Indian old fields" by the pioneers, were cleared for agriculture by burning the undergrowth and "deadening" the larger trees by making incisions into the sapwood. This process killed the trees and permitted sunlight to penetrate the forest floor.

The diminishing yield of clearings after several years of use necessitated making new openings elsewhere in the forest, and usually Indian villages were removed to new sites as well. The periodic relocating of villages and fields widened the range of Indian influence by extending farther into the uninhabited Blue Ridge Mountains.

Indian burning probably even affected the species composition of the Blue Ridge forests to some extent. Oaks and chestnut are more fire resistant species than other hardwoods, and visual evidence of large lateral branches proves that at least some of these trees were growing under very open conditions many years ago. It is suggested here that the Indians were not only responsible for clearings in the Blue Ridge forest but also that they intentionally promoted the growth of oak-chestnut trees as a forest edge around the perimeters of such clearings. Fire kept the forest floor open and rid it of growth competitive with the highly valued nut-bearing trees (Brown 1948). It is interesting to note that Big Meadows was almost completely surrounded by chestnut stands prior to 1930 (Fig. 11). These chestnut

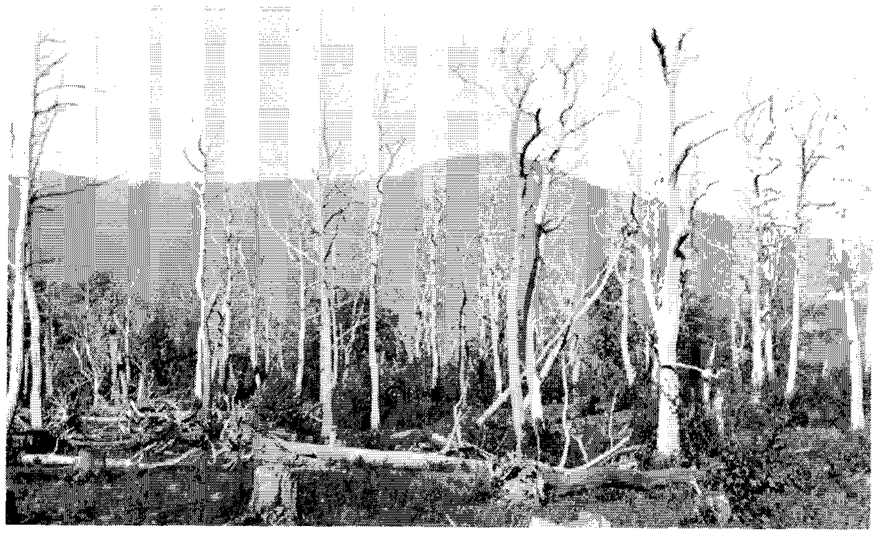

FIG. 11. A "ghost forest" of dead American chestnut trees near Big Meadows, Shenandoah National Park. Photo courtesy of the National Park Service, 1944.

stands were appreciated just as much by the mountain folk as the Indians before them.

It will be recalled that the effects of widespread Indian burning were much in evidence at the time of pioneer settlement. One forest specialist concluded that early explorers and initial settlers everywhere in Virginia found forest openings made, or supposed to have been made, by Indians for the purpose of hunting and agriculture (Maxwell 1910). Indians burned the Blue Ridge forests to keep the underbrush down; to attract deer and elk to centrally located grassy clearings for easier hunting; to drive and gather game; to control chiggers, ticks, insects, and poisonous snakes; to clear the forest floor of natural litter before chestnut collecting time in the fall; to encourage large blueberries and strawberries; and to fertilize and make the soil more friable where agriculture was practiced. Meadows, barrens, glades, and junctions of animal trails were clearings maintained and enlarged by recurrent Indian fires (Prunty 1965). Thus, despite the disappearance of Indians from the Blue Ridge district in the mid-seventeenth century, numbers of clearings of Indian origin persisted in all parts of the study area until the arrival of the initial settlers. As Prunty (1965: 167) concluded:

> The Indians certainly did not *intend* to create a suite of ecological conditions via fire that would facilitate invasion and settlement by whites. But that they did so, thereby creating a variety of settlement alternatives in widely distributed sites throughout the South, is quite clear.

The arrival of the European settlers marked the continuing of changes in the Blue Ridge landscape. Houses were built, forests were cleared, and soils were plowed. Conservation as a concept did not disturb the pioneers. They had to wrest a living from the land with simple implements by dint of hard labor. The cultural practices they followed were in keeping with their meager resources, which were basically calculated to satisfy immediate needs only. Thus logging, grazing, and burning were necessary mountain activities which sustained life.

After the Civil War a series of external and internal factors quickly led to difficult times in the Blue Ridge. These various aspects of change are beyond the realm of this report, but one of the most serious implications was the acceleration of destruction to the landscape mostly by outsiders. An increase in the mountain population and the moving in of large lumber and mining companies placed a heavy pressure on the forest lands. The slash that was left from logging operations and the brushy ground cover that grew in the clearings produced hotter fires than those burned in the relatively thin understory of the oak-American chestnut climax forest.

For 200 years fires were intentionally set by the mountain folk to improve pastures and clear new tracts in the forest for small field agriculture. In order to hasten the growth of new shoots in spring, the people often burned off the winter's dead leaves and forest debris. Again in the early fall they burned the forest floor to make it easier to find and collect fallen chestnuts. Fires that started accidentally were allowed to burn themselves out, provided they did not endanger mountain homes or human lives. Often, however, such fires got out of control and burned whole segments of the landscape. The people also burned to control ticks, chiggers, and snakes, to

TABLE 2. AREA BURN BY YEARS

Year	Total Acreage
1925–1930*	19,640
1925	1,560
1926	610
1929	1,440
1930	38,810
1931	2,930
1932	80
1933	468
1934	1,134
1935	105
1936	764
1937	186
1938	56
1939	119
1940	4
TOTALS:	67,906

* Includes all burns mapped within south end of park. Source: Berg and Moore, Forest cover types of Shenandoah National Park, 1941.

encourage the growth of larger blueberries and strawberries, to fertilize the soil, and to make the soil more friable (Wilhelm 1968).

The worst conflagrations occurred during the period of most active logging between 1890 and 1920 (Peattie 1943). The result was to destroy the finest trees of the most valuable species, leaving the species of little commercial value (e.g., dogwood) to multiply. Perhaps as much as 90 percent of the study area was logged off, burned, overgrazed, and eroded by 1930. It has been calculated by ground surveys that approximately ⅓ of the total acreage presently occupied by Shenandoah National Park was burned between 1925 and 1940 (Table 2).

It is readily noted (Table 3) that the greatest amount of burned acreage occurred in forest types (oaks-pitch pine) associated with the high ridge and the south-facing drier slopes. The pitch pine is a good example of a pyrophytic species that may have spread its range during the high conflagration period. Table 2 illustrates that the prolonged drought of 1929–1931 established climatic conditions conducive to a maximum fire incidence rate.

The substantial progress made in the prevention and suppression

TABLE 3. AREA BURNED BY FOREST FIRES

Forest Type	Burned 1925–1932	Burned 1933–1940	Total 1925–1940
Chestnut Oak	31,942	897	32,839
Red Oak	7,608	483	8,091
Cove Hardwoods	584	65	649
Scarlet Oak	9,291	232	9,523
Pitch Pine	9,339	671	10,010
Bear Oak	6,149	56	6,205
Black Locust	130		130
White Pine	57		57
Open—Grassland		22	22
Open—Restocking	320	60	380
TOTAL ACRES:	65,420	2,486	67,906

Source: Berg and Moore, *op. cit.*

of fires since National Park Service protection began in 1933 is clearly reflected by comparing the fire record for three 5-year periods (Table 4).

The decline of incendiary and debris burning fires, the increase in smoker-camper causes, and the constancy of man-caused fires in general since 1933 are quite evident (Table 5). Although progress has been made in the reduction of fires, prevention and suppression of man-caused fires continue to be the major fire control problem in the park. Oral and visual appeals are made to the park neighbors and visitors through talks, literature, fire danger signs, and the mass media to avoid starting wildfires in the park.

Some of the residents in less accessible hollows on the western border of the park have an unfriendly attitude toward Shenandoah. All seem to want vengeance against the National Park Service for evicting them from park lands. A few persons have been convicted for setting fires in and near the park during dry periods in the 1950's. These local inhabitants are potentially high fire risks to the park,

TABLE 4. FIRE RECORD—SHENANDOAH NATIONAL PARK

Period	No. of Fires	Acreage
1933–1937	96	2,307
1949–1953	69	919
1958–1962	43	94

Source: Shenandoah National Park fire records, 1965.

TABLE 5. CAUSES OF FIRE IN SHENANDOAH NATIONAL PARK*

Cause	1933–1937 Fires		1958–1962 Fires	
	No.	Per Cent	No.	Per Cent
Incendiary	50	52.1	15	34.0
Smoking	11	11.5	9	20.9
Debris Burning	13	13.5	5	11.6
Camping	2	2.1		
Railroad	1	1.0		
Miscellaneous	14	14.6	7	16.3
TOTAL MAN-CAUSED	91	94.8	36	83.7
Lightning	5	5.2	7	16.3
TOTAL ALL CAUSES	96	100.0	43	100.0

* Based on comparison of earliest and latest 5-year periods of park protection.
Source: Shenandoah National Park fire records, 1965.

although relationships with them have improved substantially in the past few years. Interestingly, lightning-caused fires have remained fairly constant through the years, but because of the great reduction in the number of man-caused fires the percentage of lightning fires has risen to over 16 percent.

Usually two fire seasons occur each year in Shenandoah National Park: the spring season from about 15 February to 15 May, and the fall season from about 15 October to 15 December. April is the worst month of the year for fire occurrences; since 1933, 21 percent of all recorded fires have taken place in that month.

RECENT PERIOD OF VEGETATIVE PROTECTION

Undoubtedly the forest formation has returned to the Blue Ridge since the creation of Shenandoah National Park in 1935. As recently as 1941 about 16 percent of the area was still open land (Berg and Moore 1941). This designation comprised those areas previously cleared of their forest cover for use as pastures, orchards, or field crops. For discussion purposes, open lands were divided further into open cultivated-grassland and open restocking categories.

Open cultivated-grasslands were essentially meadows on which no, or very little, woody growth was evident at the time of the field

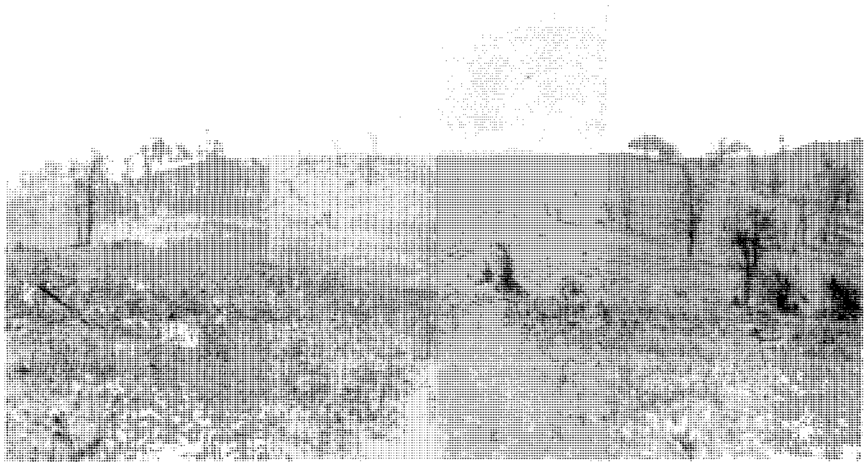

FIG. 12. Forest remnants on the Blue Ridge landscape. Exact locality and date are unknown, but the photograph was taken by the National Park Service about 1930.

survey. Some areas had been recently (early to mid-1930's) grazed or cultivated, while other lands had been abandoned for a longer period of time (Fig. 12). Open restocking areas were those lands in the transitional, successional stages between completely open and completely reforested types. At the time of the field survey in 1941, open restocking areas constituted 10.5 percent, or 20,200 acres, and open cultivated-grasslands 5.2 percent, or 9,250 acres, of the total park area of more than 190,000 acres. In 1970 approximately 30 years after the survey, field reconnaissance disclosed that less than 5 percent of the park is open land of any type (Table 6). The two largest clearings, Big Meadows in the central district, and Sawmill

TABLE 6. OPEN ACREAGE IN SHENANDOAH NATIONAL PARK

	1941		1970	
Type	Acres	Per Cent	Acres	Per Cent
Open Restocking	20,200	10.5	—	—
Open Cultivated & Grasslands	9,250	5.2	—	—
TOTAL	29,450	15.7		1 to 3*

* Figures stated in correspondence with Mr. R. Taylor Hoskins, Superintendent, Shenandoah National Park, July 26, 1971.

Source: Berg and Moore, *op. cit.*, personal field reconnaissance, 1970.

Ridge area in the south district, are mowed by the National Park Service each fall.

Personal familiarity with park clearings over the last 15 years, personal photographs, and vegetation photographs in the park files show dynamic ecological evidences of change in these areas since 1933. I have recognized four successional stages of development in the vegetation between open lands and forest types.

FIG. 13. Stage 1 of vegetation succession in Shenandoah National Park clearings is dominated by a rich assortment of grasses and sedges. Note the milkweed in the foreground. Photo taken by the author in July, 1968.

Stage 1 (1933–1940): Meadow and field species of grasses, sedges, and forbs dominated the scene (Fig. 13). Wildlife included the gray fox, woodchuck, marsh hawk, horned lark, meadowlark, and grasshopper sparrow, all typical breeding species of the open fields.

Stage 2 (1941–1946): Species of grasses and sedges greatly diminished or disappeared. Numerous forbs (Fig. 14), like oxeyed daisy, black-eyed susan, yarrow, milkweeds, wild indigo, and daisy

FIG. 14. Stage 2 of vegetation succession in Shenandoah National Park clearings is dominated by bracken fern and many species of forbs. Photo taken by the author in June, 1968.

FIG. 15. Stage 3 of vegetation succession in Shenandoah National Park clearings is dominated by brambles, shrubs, and black locust saplings shown here. Photo taken by the author in September, 1968.

fleabane profited greatly by the release from high grass shade and vigorous competition. Forbs increased tremendously in number and extent. Brambles and shrubs dotted the middle of clearings and were well established around the perimeters. Wildlife species of open fields disappeared. Breeding species of birds like the vesper, chipping, and field sparrows and the bob-white appeared in place of the former types. Transient and summer visiting white-tailed deer increased in numbers.

Stage 3 (1946–1960): Species of forbs were scarce. The New Jersey tea, fly-poison, goldenrods, asters, and ironweeds mingled with bracken fern, brambles, and shrubs in the center of clearings. *Crataegus* spp., hazelnut, and *Ribes* spp. were growing vigorously and covered a large part of the clearings. Tree species like the black locust, sassafras, Virginia pine (Fig. 15), pitch pine, white pine, scarlet oak, blackjack oak, and post oak were well established plant communities around the perimeters. The trees varied in height between 10 and 20 feet, depending on slope, soils, exposure, and the like. Vesper, chipping, and field sparrows continued to breed during this stage in the less woody centers. An influx of breeding brown thrashers, catbirds, and towhees was apparent. The bob-white popu-

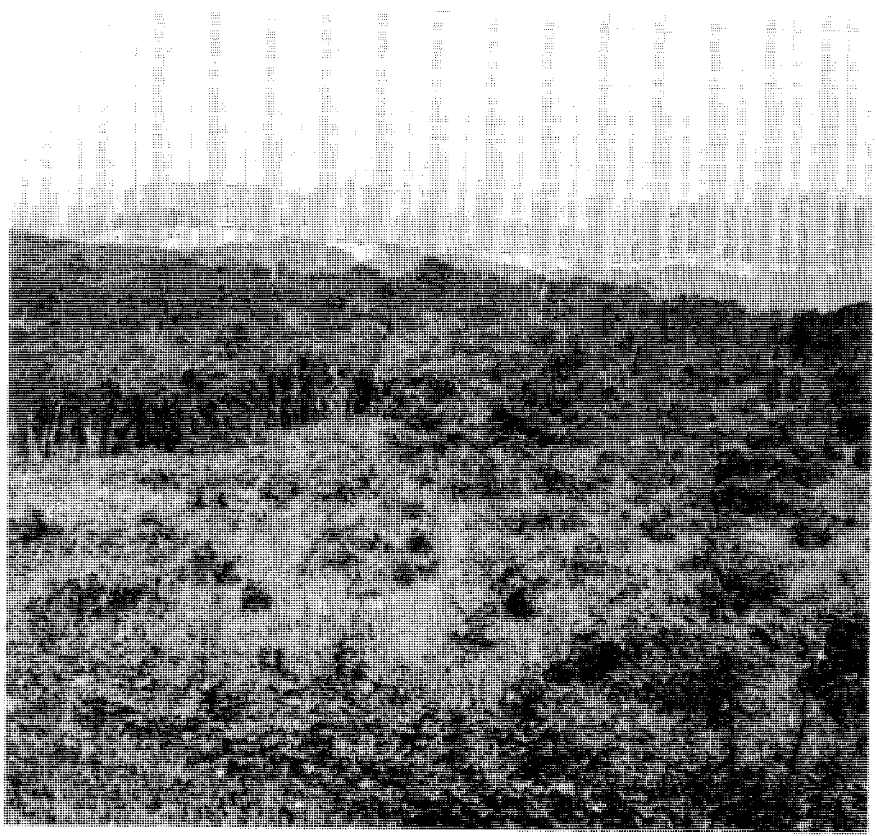

FIG. 16. Stage 4 of vegetation succession in Shenandoah National Park clearings is dominated by pine, oak, and tulip tree saplings shown here. Note the dense woody vegetation in the background. Photo taken by the author in June, 1964.

lation declined, whereas the population of transient and summer visiting deer reached its zenith in this successional stage.

Stage 4 (1961–1971): Oak-hickory, oak-pine, or oak-tulip-tree communities now dominate the former clearings. Presumably, if left unmolested, these types will mature into climax forests similar to those of native origin described earlier in this paper. Already the oak-hickory stands have attracted species of wildlife, such as the black bear, wildcat, turkey, ruffed grouse, wood thrush, scarlet tanager, and rose-breasted grosbeak, which are biological indicators associated with the former prevalent oak-chestnut climax forest (Fig. 16).

MANAGEMENT OF PARK CLEARINGS

Shenandoah clearings present a dichotomy in park management, one that is not easily resolved. The park is primarily a sanctuary of natural phenomena, and as such falls into the National Park Service management category of "natural areas." However, by virtue of historic circumstances, the park story is associated with man's influence on the local environment and the environment's influence on man. The dichotomy is further illustrated by specific park goals as outlined in the Park Master Plan. Objective II, section 1, states that the park intends to "continue to return to a natural state as much as possible the lands once utilized by man for lumbering, home sites, and agricultural pursuits." At the same time, section 5 of the same objective reads that the park will "provide for the preservation of pastoral landscapes and the memorabilia left within the park by the mountain people that qualitatively demonstrate, in authentic fashion, the mountain culture in such a manner that future generations may also experience the scene."

Undeniably, park clearings constitute a very striking, different, and now uncommon feature amidst the widespread forest lands. Moreover, the clearings are a significant part of the park story of man and mountain; for that reason the National Park Service has decided to retain the clearings. But how?

The areas had been kept open for decades, probably centuries, by lightning and Indian fires and by the grazing activities of wild ungulates. Later, white settlers substituted domestic livestock for the wild ungulates, but man-caused fires continued, perhaps even accelerated, on an annual basis until the establishment of the park.

To date, management policy for park clearings has been to maintain them as open areas by mowing them every fall, so timed (usually November) as to interfere as little as possible with the seasonal aspects of wildflower displays. None the less, annual mowing has not prevented nature from moving slowly through successional stages toward the climax oak-hickory forest now surrounding the clearings.

Empirical evidence indicates, therefore, that mowing is keeping the clearings open, but at the same time the clearings are losing their biological nature of meadows. It is suggested here that new management procedures are called for if the park intends to retain the biological significance and historical charm of the clearings. Controlled burning is the only method that has logical application.

CONTROLLED BURNING

In recent years the National Park Service has broadened its concept of purposeful management of plant and animal communities. In a few parks active manipulation of habitat is being tested, as for example, in Everglades National Park and in Sequoia National Park, where controlled burning is now used experimentally to maintain certain ecosystems with their interesting animal and plant life. Thus National Park Service precedents for controlled burning have been established.

Park clearings represent a microcosm of historic Shenandoah National Park. A reasonable illusion of former park clearings can be created by controlled burning, using the utmost skill, judgment, and ecological sensitivity. This must become the primary management objective for the clearings.

On the other hand, reluctance to undertake biotic management of park clearings via controlled burning will never lead to a fully realistic presentation of the clearings at the time of white contact when it was maintained by fire and grazing. As the famous Leopold report stated: "Of the various methods of manipulating vegetation, the controlled use of fire is the most natural and is both relatively cheap and easy to apply." Certainly the clearings will require careful advance treatment and training of personnel before even the first experimental blaze is set. Trees and mature brush will have to be cut, piled, and burned before a creeping ground fire is risked. Once natural fuel is reduced, annual burning can be conducted safely and at low expense.

Interrelationships among the various meadow grasses, sedges, and forbs, as well as those between the herbaceous growth and woody forms, is most complex and little understood. Suffice it to say that these relationships vary extensively across the clearings, depending on relief, soils, microclimates, and many biotic factors. Not the least of the latter is the influence man has had, and is having, upon them. However, it is beyond the scope of this report to stress these interactions. Still, the intricate associations and interrelationships involved in the ecological processes of meadow life constitute an exciting realm for future park research.

If controlled burning is to be used in park clearings, then I recommend that such fires occur in late summer. Cooper (1961) has shown experimentally that summer fires have a much more profound effect on the control of woody growth than late fall or winter fires. I believe that late summer fires, preferably after Labor Day, could maintain and enlarge the grassy tracts of park clearings within 2 or 3 years. This specific time for controlled burning is proposed for several reasons: 1) fewer park visitors will be present in the areas, thereby reducing problems of protection and management; 2) most of the herbaceous meadow plants and their animal associates will be past their genetically important reproductive stage; and 3) since these herbaceous plants and accompanying animal species have had to evolve under summer fire conditions in the past, natural selection processes will operate once again in the park clearings to fit them to survive under a summer fire regime. Ecologists now know that it was summer fires in the geologic past that had the most effect in "molding" the Appalachian landscape.

Even though park clearings like Big Meadows may appear to be relatively "unburnable" because of certain amounts of greenery at the end of summer, they may actually carry a rather "hot" fire.

This is true because many grasses, sedges, and forbs either lose their lower leaves by shading, or they die and remain, and the accumulation of past years forms a dry mat underneath. Add to this matting the accumulated mowed vegetation of the past several years. Under these conditions, and with proper personnel training and weather conditions, the meadows will burn.

Although the first controlled fire in the clearings could be sweeping and produce clean burns, this probably will not be the case. Park clearings now mowed by the National Park Service consist of a great many kinds of grasses, sedges, forbs, and even woody plants, in fact, too many to list in this report. These various species make up at least 12 major plant communities that will not be uniform in their ability to carry fire under the same conditions. Likewise, many of the animals that live in the clearings create conditions by their own activities (e.g., burrowing and tunneling) that cause the effect of fire to be different. Finally, park personnel will need to consider topographic-edaphic-climatic aspects of the clearings before setting guidelines and procedures for burning.

It is essential that Shenandoah National Park personnel understand, much more completely than they do now, the natural characteristics of meadow properties, the nature of the normal processes at work within them, the unnatural forces imposed upon them, and the relationships of park visitors to the clearings (Wilhelm 1969). If the park is to protect, preserve, and manage the clearings, then it must know what it is protecting and why. Basic short-term and long-term ecological research will develop the fund of knowledge necessary for intelligent and effective meadow management.

Concurrently, ecological research in park clearings will have an additional and equally important collateral product. The same research program will supply data, presented through the National Park Service interpretive programs, to enhance appreciation and enjoyment of park clearings, but more so to influence the visitor's better use of the clearings through understanding them. Such a research program will feed the interpretive programs on park clearings and maintain their vigor and substance. Further, a large segment of future interpretation must be devoted to the significant role and use of controlled burning. This will not be an easy task, but an interpretive challenge of education. It is long past the proper time when the word "fire" is used in its proper perspective in park interpretation and management, and not used solely as a taboo term.

CONCLUSIONS

Prior to becoming a national park, Shenandoah had gone through periods of indiscriminate logging, hunting, livestock grazing, and burning. Then the area entered the National Park System and shifted abruptly to a regime of being unnaturally protected from the above mentioned activities.

Although somewhat conjectural, perhaps, recent meteorological data indicate that lightning fires seem to have been a natural environmental factor in the origin of Big Meadows and other park clearings. Regardless whether lightning fires created Big Meadows or not, it is known that many clearings had been kept open for decades, if not centuries, by intentional burning, first by local aborigines, later by white settlers. The latter human element also practiced livestock grazing (mostly cattle). In fact, after the Civil War, certain park clearings like Big Meadows were quickly recognized as great beef producing centers in the Blue Ridge.

The present park policy of setting aside a part of Big Meadows to be held inviolate of any artificial treatment, use, or human influence, as indicated in the park's Master Plan, and the remainder to be maintained as an open area by annual mowing must be rejected as scientifically unsound for at least three reasons: 1) a preserved section of the meadow is on paper only; 2) mowing is in itself a human artificial influence; and 3) mowing has kept the meadow and other park clearings open but has not stopped the ecological processes of succession from progressing toward the climax vegetation of oak-hickory forest.

The simplest, most economical solution to prevent a climax forest from dominating park clearings is to use controlled burning, executed by trained park personnel in the late summer (after Labor Day) when park visitors are fewer in number. If for no other reason, park clearings should be preserved as a part of the important story of human use of the area. In this context, Shenandoah National Park could become a valuable scientific outdoor laboratory. In fact, one of the primary values that sets the park apart from all others in the National Park System is the opportunity to observe, study, and interpret dynamic ecological processes in an area that has been altered by past human actions. There are many former park clearings where these ecological processes can be studied without further intrusion of artificial influences.

However, I believe that Big Meadows and the Sawmill Ridge district of Shenandoah National Park are too strategic and important to the park story to allow nature to take its own course. In fact, it is further suggested that the park administration seriously consider reconstructing both clearings as they were in the eighteenth or nineteenth centuries. I am recommending a reinactment of living ecological history, with proper biological, environmental, and cultural traits evident to future park visitors. Such an idea would entail the use of controlled burning, livestock grazing, and the reconstruction of a mountaineer farm with its fitting material culture. In this way Shenandoah National Park will be meeting its objective in providing for the preservation of an important pastoral landscape in an authentic fashion so that present and future generations may also experience the scene.

The above suggested program is doubtless contrary to some National Park Service policies, at least in their narrowest interpretation. But I believe that the time is ripe for bold, scientific action, for the importance of the problem amply justifies the departure. It is worth emphasizing that Shenandoah National Park is a long-term project in landscape management, and that the problem of man, nature, and fire promises to remain. Thus I can see no other real solution.

The apparent park dichotomy between preserving the natural environment and saving the mountain culture is in reality a symbiotic relationship between man and mountain. Only Shenandoah National Park among all the national parks has the unique opportunity to reconstruct a total meadow landscape. In the final analysis, the authentic Shenandoah story is a blending, not a separation, of intricate man-land relationships.

ACKNOWLEDGMENTS

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