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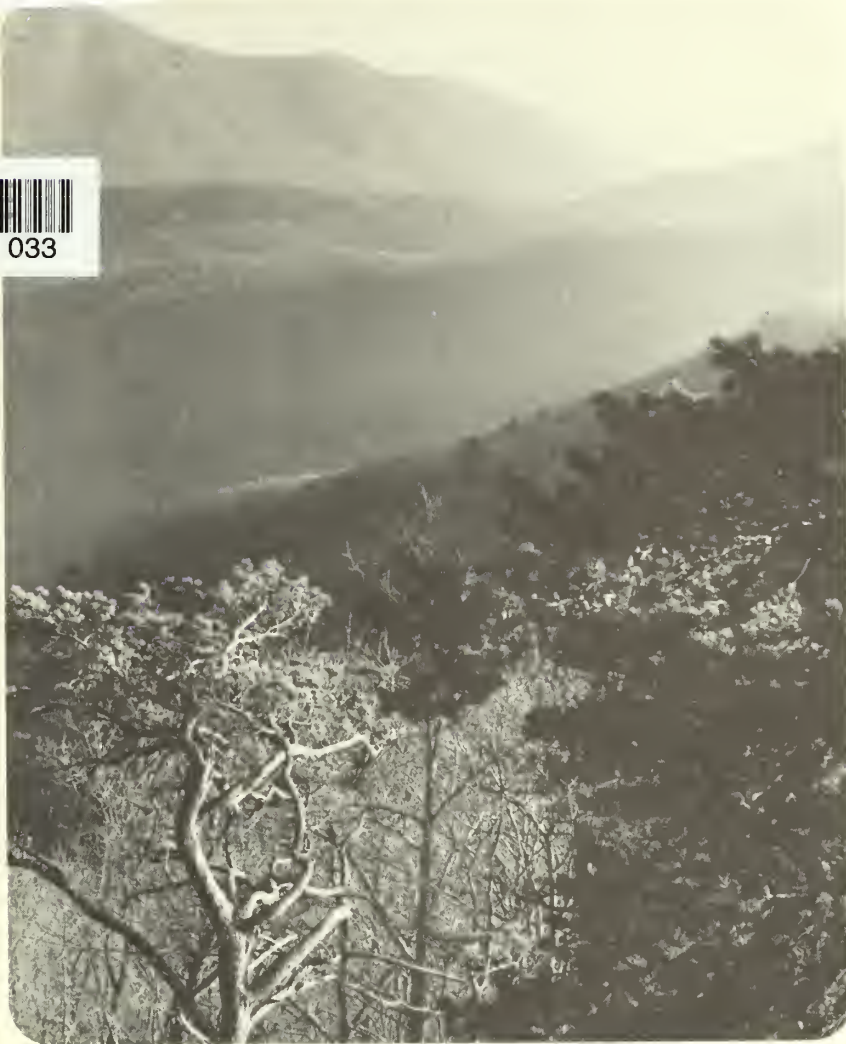


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National Park

First Annual Shenandoah Research Symposium
April 1976



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Shenandoah

National Park

First Annual Shenandoah Research Symposium
April 1976

National Park Service
Mid-Atlantic Region
143 South Third Street
Philadelphia, PA 19106

PREFACE

This volume includes papers presented at the First Annual Shenandoah Research Symposium held at Shenandoah National Park, April 9-10, 1976. The papers cover such topics as plant sucession on abandoned homesites; vegetation responses to management burning at Big Meadows, Shenandoah National Park; a spring burn's impact upon vertebrates at Big Meadows; a consideration of black bear populations in Virginia; and the Shenandoah salamander.

Some of the papers report on research projects conducted in cooperation with Shenandoah National Park but at no park expense. The National Park Service strongly endorses such mutually beneficial research whereby the Service acquires professional studies about its parks, and researchers are afforded opportunities to utilize park resources.

Superintendent Robert R. Jacobsen initiated the symposium because of his enthusiasm for cooperative research at Shenandoah National Park. He intends to continue welcoming such scholarly study there and values the associations it produces with colleges and universities. He would be delighted to respond to inquiries about possible future research, which should be addressed to:

Superintendent Robert R. Jacobsen
Shenandoah National Park
Luray, Virginia 22835

We wholeheartedly support Mr. Jacobsen's interest in cooperative research and believe that his symposium was one of the Region's outstanding activities in 1976.

Benjamin J. Zerbey
Acting Regional Director
Mid-Atlantic Region

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VEGETATION RESPONSES TO CONTROLLED
BURNING AT BIG MEADOWS

W. Dean Cocking*

The fire ecology project at Big Meadows in the central section of Shenandoah National Park is a cooperative effort involving local park service personnel, scientists from several educational institutions and Dr. Robert Stottlemeyer from the Mid-Atlantic Regional Office of the National Park Service. The experimental prescribed burns carried out in the Spring of 1975 for the purposes of our study were the result of efforts by Ray Schaffner, Robert Jacobsen, Clark Baker, and many others. This paper will describe some of the preliminary results of our participation in the project. The majority of the field work was carried out by Steve Lilly and Emily Baxter, graduate students in the Department of Biology at Madison College. We have been looking at the growth rates and community composition of the regenerating meadow vegetation and hope that the resultant data, combined with the soil and faunal observations of Dr. Norman Christensen and Dr. Peter Dalby, will give a complete picture of the ecosystem response to prescribed burning.

Big Meadows is at an intermediate stage of secondary succession and is therefore similar to the majority of the communities within Shenandoah National Park. The progress of succession at this site, however, has been periodically set back by fall mowing, the frequency of which has increased during the last decade until it is now virtually an annual occurrence. The purpose of this management practice has been to maintain open space adjacent to the Byrd Visitor Center and has resulted in a mosaic of herbaceous "grassland" and shrub "briar" communities. The increasing size of black locust stems over the last decade has made the mowing practice more difficult, and this project is designed

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to look at the feasibility of using fire to maintain the earlier stages of succession. Without some form of management, the meadowland will disappear and young successional forest will take its place.

The present mowing technique has two major disadvantages. First, it is an increasingly expensive and time consuming endeavor. Second, it appears to be stabilizing the community as a shrubland of Rubus spp. (blackberries and dewberries) and Robinia (black locust). Should this happen, the herbacious species will disappear from the region due to their inability to compete successfully. Information from this study will be helpful in making management decisions concerning whether mowing, burning or a combination of both will be appropriate in the future.

Sixteen small plots (approximately $\frac{1}{4}$ acre each) were selected within the dry, upland part of Big Meadows. One half were in the "grassland" community type and the rest in the "shrub-briar" community. Within each community type two plots were mowed as usual in the fall of 1974, two were burned on April 15, 1975, two received both treatments, and two received neither treatment and served as experimental controls.

Detailed discussion of the data from this study will be presented later, along with the results of a much more extensive spring burning carried out last week. However, it is possible to discuss some of our observations at this time. One of the primary investigations concerned the immediate effects of the burn on the physical environment. Temperatures during the burn were approximately 300 to 350 °C, a relatively warm fire, but not extremely hot in comparison with temperatures attained in some forest fires. We examined soil temperatures five days after the burn and found slight increases in the blackened areas as a result of the greater absorption of light by the dark soil surface. The impact of this warmth on spring growth remains to be established. Dr. Christianson has analyzed soil samples taken two months following the burn and reports increases in potassium, calcium, magnesium, nitrogen and other ions. This greater nutrient mobility may promote better growth during the subsequent summer, however, this also remains to be determined. Another question which interested us was the rate of recovery from burn to green meadowland. Regrowth was extremely rapid in all burned plots, and very little evidence of the fire remained by mid-summer.

Quantitative assessment of the burn impact was carried out in two ways. We sampled the tissue by physically

collecting the above ground vegetation, drying it in an oven, and determining the dry weight of living and dead components of various species groups. We also used a sampling frame to determine the amount of soil surface area covered by the individual species. Recovery in "grassland" at the end of the growing season in August was more complete than that of the "shrubland." However, both community types were very repairable following the prescribed burns.

We are also interested in changes in species composition of the communities which might result from the use of burning as a management practice. Initial examination of the data indicates that some species, e.g., the Fragaria, Solidago, Achillea, Potentilla and Rubus, increase in relative cover while others, such as Dennstaedtia, Polytrichum, Lycopodium and Robinia, decrease following the burn treatment. The dynamics of these species composition changes will hopefully become more evident following the present study.

In conclusion, we feel assured from the initial project that burning and mowing are similar in their effect on the community and that the use of fire to set back succession will not result in prolonged damage to the ecosystem. We are not presently in a position to predict the effect on individual species. However, we do know that species present in the meadow are dependent on the open conditions of herbaceous and shrub communities and will certainly disappear if the community completes the successional process and returns to forest.

EFFECTS OF A SPRING BURN UPON
THE VERTEBRATE COMMUNITY AT BIG MEADOWS,
SHENANDOAH NATIONAL PARK

Peter L. Dalby*

I hope to make this presentation a bit broader in coverage and possibly a bit more philosophical in nature than just examining the effects of a spring burn upon the vertebrate community at Big Meadows. Since plants and animals are difficult to separate completely from each other because of their interrelationships, you will note some overlap with the report given by the plant ecologist on this project, Dr. Cocking.

Before progressing further, I would like to acknowledge the support of the National Park Service, Tall Timbers Research, Inc., an organization dedicated to fire ecology research, and of course, the Shenandoah Natural History Association. A past V.P.I. & S.U. graduate student, John Niess, also contributed to the earlier portions of this study. The field work was completed while the author was associated with V.P.I. & S.U.

Superficially, and from a non-ecologist's viewpoint, one might accept the argument that the use of fire is warranted simply to determine if it is an effective and economical tool for maintaining cleared areas. Overlooks, old homestead sites, and others such as Big Meadows fall into this category. Does mowing, brushing, or bush-hogging such sites create more, the same, or less damage than a controlled burn? Which technique, the time-honored method or burning, is most successful in reducing unwanted species for the longest period of time? Above all, what is the cost-benefit ratio built into the time-honored methods versus controlled burning?

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As interesting as the above questions are, studying the effects of controlled burning in Big Meadows has progressed further than simply attempting to reduce the ubiquitous black locusts (Robinia pseudoacacia) and briars (blackberries, Rubus sp.). An attempt is being made to monitor the kind and the intensity of change due to fire, both to the plant and the animal community. In other words, more than a casual examination is being given to the locusts and briars, two of the major early succession woody plants invading Big Meadows and other open areas in the park. Less dominant and less conspicuous species are also being qualitatively and quantitatively sampled. It is important to document not only how the fire directly affects the animal life, but also how the change in vegetation affects the local fauna.

There is an amazing dearth of information concerning the effect of fire upon the flora and fauna of the eastern United States. This is in sharp contrast to the respectable data bank accumulated for the western and also for the southeastern United States. Most of this information was gathered by those interested in forest management or forest recovery; much less is known of the effects of fire upon grasslands, particularly as it pertains to the eastern United States.

There are several reasons why Big Meadows was chosen for the burn project over other areas within Shenandoah National Park. First, Big Meadows is the largest (125-150 acres) high altitude (3500 ft. or 1067 m.) grassland meadow in the park. Therefore, it allows a great deal of flexibility concerning experimental design, especially as it pertains to plot size and number. Second, it is logistically ideal because it is reasonably centralized in respect to the institutions involved in the study and it is near a road and housing/camping facilities. Third, the importance of Big Meadows, both in the past and the present, serves as an additional rationale for efforts to preserve its exceptional qualities without further delay.

There is some evidence that the Indians maintained the field condition of the Big Meadows area through the use of fire. Strawberries, blackberries, and blueberries were abundant during various portions of the summer; probably other "crops" were gathered also. In addition, the meadow certainly attracted bison, elk, white-tailed deer, several species of rabbits and hares, woodcock, and probably other game species.

Presently, Big Meadows is a focal point in the park's camping and naturalist programs. Birding, watching for

deer and other mammals, identifying flowers, and general hiking activities are only a few features which make Big Meadows so popular. As the forest tends increasingly to dominate the park scene, clearings such as Big Meadows present an alternate vista of openness to the park visitor. More importantly, Big Meadows and other open areas in the park serve as a refuge for a number of plant and animal species partially or solely dependent upon a grassland community for their existence.

Methodology

Because of the plot sizes agreed upon by all those involved in the project (see Dr. Cocking's presentation for a description of the plots), it was decided for at least the first year to concentrate mainly on sampling the invertebrate soil and litter fauna. This is for very obvious reasons. They are plentiful, and there are good sampling techniques so statistical analysis of the data is reasonably easy. We hope to examine the small mammal (rodents and shrews) and bird communities, however, the plots are rather small for this kind of work. Although the data that can be gathered may be meager, it still provides a ballpark estimate of what happens as a result of controlled burning.

The collection of invertebrates was done during ten sampling periods, at three week intervals, starting in April and finishing at the end of October. By using a stratified random design, four soil and litter samples were taken from each 25 m. square plot. The sampling was taken with a 10½ inch (25 cm.) diameter metal band, about 5 inches (12½ cm.) in width. With the band encircling the sampling area, a shovel cut the sod along the inner perimeter of the band. Then the 1-2 inches (2.5-5.0 cm.) thick plug of sod was pried loose, placed into a plastic refuse bag, and sealed.

At the university, usually half of the samples were placed in a cooler (5°C) and the remainder processed immediately. A Berlese funnel system was constructed in order to extract the invertebrates. A cloth cover over the funnel prevented escape from the top. A lamp over each funnel provided enough heat to drive the invertebrates out of the soil and into a jar (containing a solution of 90% ethyl alcohol) attached to the funnel. After a week the sod was discarded and the jars containing the results were capped and stored until the material could be identified. The remainder of the samples which had been under refrigeration were then placed on the funnels. Approximately 500 samples were collected and processed.

The small mammal community in the study plots was monitored by using an approximately equal number of small (54 x 64 x 171 mm.) and large (75 x 75 x 227 mm.) Sherman live traps. Nine traps were placed in each 25 m. square plot, following a grid pattern in which the traps were set at about 8 m. intervals. Rolled oats was used as bait, and the traps were set at dusk and checked the following morning. This procedure was followed for two consecutive nights. Trapping occurred at the beginning of the study, just prior to burning, again during the middle of the summer, and lastly in October at the termination of the study. A total of 648 trap-nights (one trap set for one night equals one trap-night) were accumulated.

The birds were periodically watched during the season, particularly by Mr. Niess, who was employed as a summer naturalist at the Big Meadows Visitor's Center. Most of the observations were taken during the beginning of the study when home territories and feeding areas became established. The results of this portion of the study are of a qualitative nature. When the opportunity arose, observations on other animal species were also taken.

Preliminary Results

The Burlese funnel invertebrate material remains to be identified and I have no preconceptions about changes that might have occurred during the study. However, we were able to make some observations. Of considerable importance to the pollinating insects was their use of the unburned and unmowed briar patches as a food base during the spring blossoming period. One of the interesting facts concerning briars is that they are biennial plants, and, once mowed or burned back to ground level, any recovery during that growing season is entirely vegetative. Flowering occurs only on second year and older cane. With the annual mowing and bush-hogging which has occurred for the last 30 or so years on Big Meadows, pollinating insects have certainly had one food resource literally cut out from under them. Annual use of fire will have the same effect. Although the smaller blueberry bushes could escape the mowing operation, the others were trimmed to the point where they too did not flower to any appreciable degree until the second year. Fire had the same effect; in fact fire might be a bit more severe in the sense that fewer stems escape damage. As a result, the pollinating insects had two plant types eliminated from their food resources. Certainly later in the year these same plants, if allowed to flower, would have provided a substantial amount of fruit for many fruit-eating species of insects, birds, and mammals.

As for small mammals, essentially nothing was found. In the spring one adult short-tailed shrew (Blarina brevicauda), was found dead during an invertebrate sampling period. It may have been killed by a fox and discarded because of their apparent ill taste. One subadult meadow vole (Microtus pennsylvanicus) was captured during the last trapping period of the season. Such a paucity of small mammal life in Big Meadows has existed for quite some time as evidenced by trapping records for the last 5-10 years on file at park headquarters. I would speculate that part of the reason might be due to the large biomass of nonvascular plants (mainly mosses) found on the study sites. Over the years, mowing has probably favored that type of growth over the grasses and sedges. I suspect that by the proper use of fire, one can increase the amount of sedge and grass cover. In fact, Dr. Cocking's report tends to verify this. With a larger biomass of sedges and grasses there might be an increase in the number of meadow voles. This in turn could tend to increase the number of owls, hawks, skunks, and foxes, all of which prey to some extent on this species. In other parts of Big Meadows, for instance, in some of the lower and higher areas away from the study sites, there are limited patches of dense grass cover inhabited by meadow voles, as discerned by observation of their runways. These mice can serve as nuclei for future invasion into other parts of Big Meadows.

There are only about a half dozen woodchuck (Marmota monax) holes near or within the study sites, but one quickly notices that these are almost exclusively found in the briar thickets, although the animals' feeding usually takes them out of this cover. If an attempt is made to eliminate all the briars from Big Meadows, it is certain to have a dire effect upon the woodchuck population. From much walking in Big Meadows I would estimate that there are 50-100 active woodchuck dens, nearly all associated with the briar and to a lesser degree the locust (1-3 m. in height) stands. The preference of some low woody growth around potential den sites is well documented for woodchucks and its elimination or reduction will decrease the woodchuck population. This might not be entirely undesirable except it must also be kept in mind that rabbits, skunks, and other species, including some amphibians and reptiles, also utilize the same holes.

The information on birds is mostly qualitative in nature. There are several generalizations which can be made, however, concerning the effects of the burn upon them.

1. Fire does not seem to have an immediate negative effect on birds. In fact, several species which appear to prefer feeding areas with short cover,

such as robins (Turdus migratorius), vesper sparrows (Poocetes gramineus), grackles (Quiscalus quiscula), and starlings (Sturnus vulgaris) seemed to be more frequent in burned than in unburned areas. This activity continued until the new growth was well established by mid-summer. The loss of leaf litter and possibly the warming of the soil made the bird prey more visible and probably more active because of the warmer soil temperatures. It is obviously difficult to determine whether a bird has a behavioral preference for a particular habitat or is at a site because of food availability.

2. Vesper sparrows, song sparrows (Melospiza melodia), field sparrows (Spizella pusilla), indigo buntings (Passerina cyanea), bluebirds (Sialia sialis) and possibly a few others selected the burned, but still standing dead cane of the briars, and the standing, but dead locusts, as perching sites. This observation was not discernible until several weeks into the study when unburned briar and locust sites were well leafed. It seemed to hold true under several different circumstances: a bird would alight to "rest," to sing a territorial song, or to perch between periods of foraging activity on the ground. Obviously such perching sites gave the bird a clear field of vision.
3. Two known species, namely the song sparrow and the towhee (Pipilo erythrophthalmus) nested in the standing unburned, unmowed, 1-3 m. tall locusts. While both species are common in the area, mowing or burning every 2-3 years instead of every year would insure added nesting sites for these two species, among others.
4. Burning or mowing is necessary to maintain an open courtship area for woodcock (Philohela minor). Very preliminary results suggest that courting males in burned sites remain in such sites. During a good spring evening there is no doubt, after listening to the large number of woodcock utilizing Big Meadows, that it is an important breeding ground.

Data on a number, probably a majority, of the species mentioned above are less than conclusive. However, the picture described, albeit crudely drawn, can still be recognized as a picture. Certainly the finer lines have to be added.

Other characters, such as skunks, opossums, and deer are still missing from the drawing. The herps (reptiles and amphibians) pose a special problem. There is a small population of wood frogs (Rana sylvatica), spring peepers (Hyla crucifer), and American toads (Bufo americanus) that breeds in the several small ponds situated in Big Meadows. The ponds often dry up before the tadpoles undergo metamorphosis so it is a marginal breeding site at best. Yet the number of other potential breeding sites in the immediate vicinity is unknown. Probably burning will not harm their breeding activities, but still they should be monitored.

The reptiles are represented by box turtles (Terrepenne carolina), green snakes (Opheodrys vernalis), ring-necked snakes (Diadophis punctatus), and garter snakes (Thamnophis sirtalis). The green snakes and garter snakes are typical field snakes and, as a result, are rather unique to Big Meadows. The effect of burning on their welfare is unknown. In fact, at this point there are more "unknowns" than "knowns" concerning all the above species and the effect of fire on their existence. Yet, based on what is known a few concluding remarks can be made.

Concluding Remarks

Big Meadows owes much of its uniqueness to its great diversity of plants; the diversity of animals found at Big Meadows is partly dependent on this plant diversity. The complex, mosaic distribution of plants and animals within the meadow allows for the following:

1. Certain animal species are dependent upon essentially a single plant species habitat. For example, if you have a pure species stand of briars, then very likely there are going to be a certain invertebrate and vertebrate species that will, for all practical purposes, lead their entire life (or life cycle) within that briar patch.
2. Many species are ecotonal in nature. That is, some species may nest in one habitat yet move to another to forage. These species are dependent upon two or more habitat types in close proximity for their livelihood.
3. As open meadows continue to shrink every year in the park because of forest encroachment, there eventually comes a time when there is not enough room in the meadow to sustain viable populations

of either of the above two types. In effect, animals inhabiting the area are now woodland forms, the meadow forms having been extirpated.

It is the complexity, the mosaic pattern of life in Big Meadows which aids in making the area the plant and wildlife showplace that it is. There is a need to keep the complexity in order to maintain the richness, yet at the same time there must be a pureness in order to insure the survival of other species which contribute to the area's richness. Is mowing or fire the best management technique to use in order to sustain or even increase Big Meadows' richness? Which-ever method is eventually utilized, burning or mowing in swaths is highly recommended, following a 2-3 year rotational program. This by itself will be an improvement over the practice of mowing the whole field every year. Burning or mowing should be done as early (burning) or as late (mowing) as possible in order to minimize damage to the animal (and plant) community. Burning or mowing should be thought of as successful management tools only if they can control in a more or less steady-state condition the complex of plant and animal life presently found on Big Meadows. In other words, the spread of briars and locusts is to be controlled; there is no desire nor ecologically sound rationale to eliminate either from Big Meadows. Finally, fire has been documented to play a very important natural role in some ecosystems. It may be that fire once played an important ecological role in this part of the country also. Fire has always been a double-edged sword for man. It is up to us at Shenandoah National Park to learn how best to use the tool that Mother Nature has been using for eons.

PLANT SUCCESSION ON FORMER HOMESITES

Elwood Fisher*

The need for this study occurred to me while I was directing a Master of Science thesis for Paul R. Lee, a Shenandoah National Park naturalist, on "A Study of the Impact of the Exotics Lonicera japonica and Alanthus altissima on the Shenandoah National Park Ecosystem." I felt that results from such an investigation would be currently useful to the interpretive staff of the park, as well as to academicians of the future.

The park is really a very unique laboratory for ecologists. It is an experimental plot of immense proportions where cultivation and other forms of land use had completely changed the natural environment in almost every section. This region, occupied by some 350 families, was almost instantly allowed to start its return to primeval conditions, providing scientists with a rare opportunity to study roles and patterns of plant succession in this ecosystem.

For the sake of clarity many plant ecologists draw rather fixed, over-simplified models of plant succession. Due to the number of variable habitats and factors of an area as large as the park, these models do not hold true when investigated under actual field conditions. In fact, succession is a mosaic of a variety of sere-types, often in areas of close proximity. The soil type, degree of mineral exhaustion, amount of erosion, exposure to sun and wind, slope, type of natural cover, local animals, fires, "mother seed trees," frost pockets, elevation, and related factors are foremost in determining the rates and patterns of succession.

Peter M. Mazzeo (1966) catalogued the species of exotics at the Skyland site. His study and the one by Paul Lee (1973) are the only published attempts at accessing the succession in any part of the park prior to my studies of former

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homesites. Basically I am trying to record the exotics that have survived, and to determine the degree of their adaptability in the midst of encroachment by the endemics. I am also trying to interpret the order and rate at which the endemics advanced into the homesite and surrounding fields. I am using increment borings to determine the age of the dominant trees on the site, when in question or if relevant. I make a plant list for each site, noting the incidence of dominant, co-dominant, common, and sparse species, both exotic and endemic.

For the most part, the techniques I have employed are the observational methods of a naturalist. I grew up in a similar environment during the depression years and can interpret and relate to the mountain farm and life-style. I used the 1927 through 1937 series of United States Geological Survey fifteen minute quadrangles in locating the sites. Though many of the old trails are no longer visible I can generally take a compass sighting from the spring to the homesite and find the house foundation readily. All homesites had a nearby spring, a prerequisite to life in the mountains.

I intend to visit each site during two seasons, spring and autumn. In the spring I look for flowering bulbs and other spring flowering plants. Late summer and autumn data catalogues plants not seen in the vernal season. At this time I have data for at least one of the two seasons for ninety percent of the sites in the Southern Section of the park. I have some data for the sites in the Central Section, but very little for those in the Northern Section.

The Lonicera japonica (Japanese vine honeysuckle) is always present on homesites at lower elevations. The Alanthus altissima (tree of heaven), Vinca minor (common periwinkle or graveyard myrtle), Syringa vulgaris (common lilac), and Hemerocallis fulva (day lily or beauty of the day) are the four exotic species of ornamentals most frequently found at all elevations. The various species of Rosa are also numerous, but it is very difficult to differentiate between the many varieties and species. Of the exotic herbs, the Taraxacum officinale (common dandelion) and Arctium minus and A. lappa (common and great burdock) appear to be most common.

Of the endemic plants, it appears that Pinus virginiana (Virginia pine), Prunus serotina (black cherry), Sassafras species, Robinia pseudo-acacia (black locust), and Crataegus species (hawthorn) are the most aggressive pioneer species of the formerly cultivated areas in the park. The soil qualities such as dryness and fertility, among other factors, determine

which of these species dominates the earliest sere. On a few sites I have found species other than the above which first colonized the vacated land, but rarely is this the case.

In addition to cataloguing the exotic and endemic plants I have kept a sharp eye for artifacts on or near each site. These items, along with the size and workmanship of the foundation of the former house, gives me some idea of the life-style and occupation of the former residents. I also record bird species and other animals seen at each site. Since the type of sere is still changing, this information may be useful to later investigators.

Hopefully I shall complete the study of the Southern Section of the park and have a manuscript prepared by 1978.

THE ENDEMIC SALAMANDER, PLETHODON SHENANDOAH,
OF SHENANDOAH NATIONAL PARK

Richard Highton*

Mr. Raybourne's paper on the black bear reviews the interesting work being done on the largest vertebrate in Shenandoah National Park. I want to talk about some of the research we have been doing on the two smallest terrestrial vertebrate animals living in the park.

The first is the Shenandoah Salamander, Plethodon shenandoah. Adults of this species are only three to four inches long. As far as we know, this salamander is found nowhere else in the world, although it has close relatives in the Cheat Mountains of West Virginia and in the Peaks of Otter area of the Blue Ridge of Virginia. Not only is the Shenandoah Salamander restricted to the park, but it is apparently confined to northwest facing talus slopes of only three of the park's highest mountains, Hawksbill, Stony Man, and the Pinnacle. On all three of these mountains the entire distribution of the Shenandoah Salamander is in each case no more than three-quarters of a mile in diameter.

The Shenandoah Salamander occurs in two color phases, or morphs, which are merely genetic color pattern variations of a single species: the unstriped or dark color morph and the striped color morph characterized by a narrow red, reddish yellow, or yellow dorsal stripe. The two morphs occur in approximately equal frequencies on Hawksbill Mountain, but the striped morph is much more abundant than the unstriped morph on Stony Man Mountain, and we have found only the striped morph on The Pinnacle.

The red-backed salamander, Plethodon cinereus, is probably the commonest terrestrial vertebrate over much of its range in northeastern United States and southeastern Canada. It

*Professor of Zoology, University of Maryland, College Park, Maryland

is a close relative of the Shenandoah Salamander and is very similar in appearance, occurring in both striped and unstriped color phases, but is usually somewhat smaller and more slender than shenandoah. Striped cinereus have a wider dorsal stripe than striped shenandoah, and the stripe is more often red than yellow. The body of Shenandoah National cinereus is slightly more elongated than that of shenandoah with an average of twenty trunk vertebrae as opposed to nineteen in shenandoah. There is more dorsal brassy-colored flecking on the back of unstriped cinereus than on unstriped shenandoah, and the belly of shenandoah is much darker than that of cinereus because the white mottling is greatly reduced.

Although the red-backed salamander occurs in virtually all the wooded areas, it apparently is usually absent from the dry open talus slope areas where there is little soil and evaporation rates are extremely high. This includes the major part of the talus slopes on Hawksbill and Stony Man Mountains, but suprisingly we have found cinereus throughout most of the talus slope on The Pinnacle Mountain where conditions are perhaps different from those in most of the park's slopes.

Most of our field work in the park was done in 1965 and 1966 soon after we discovered shenandoah. It was officially described and given a scientific name in 1967. During that period two graduate students, Richard D. Worthington and Robert G. Jaeger, and I did extensive field work on the distribution of the two species in the park. We failed to find shenandoah on any of the other high nearby mountains, even those with northwest facing rocky talus slopes.

The closest relatives of shenandoah are nettingi, which inhabits the spruce forests in the Cheat Mountains of West Virginia, and hubrichti, an inhabitant of the high deciduous forests of the Peaks of Otter region of Virginia. The distribution of the three forms is one we regard as relictual; the three presently isolated populations are now very restricted in their distributions but at one time probably had a much more widely distributed common ancestor. At first we thought that shenandoah might have subsequently become adapted to living only in rocky talus habitats, but the brilliant work of Robert G. Jaeger on the ecology of shenandoah and cinereus has clarified the reasons for their present ecological distributions, at least on Hawksbill Mountain. I am sorry he was not able to attend this meeting to tell you about his work himself.

In a series of experiments on the moisture requirements of shenandoah and cinereus, Dr. Jaeger found that both species

have similar moisture and substrate preferences: both prefer soil to rock under dry conditions but do not differ in the substrate preference in wet conditions. Probably partly because of its larger size, shenandoah is better able to withstand desiccation than cinereus. Thus shenandoah is not confined to the talus slopes because it is adapted only to this habitat; indeed it would probably do better in surrounding woodlands now occupied by cinereus. It is surviving only in a suboptimal habitat that is periodically too dry for cinereus to live in.

Dr. Jaeger did additional experiments in enclosures set up in the field in both talus and woodland habitats. Ten individuals of cinereus were placed in cages in the talus and in the soil outside the talus. All of the cinereus in the soil survived for 12 weeks, but none in the cage in the dry talus survived that long. A similar comparison of shenandoah resulted in moderate survival in the dry talus and complete survival in the soil habitat. When 10 individuals of both species were placed in a single cage, one in each habitat, shenandoah had a higher rate of survival in the talus, but cinereus had a much higher rate of survival in the soil outside the talus. Since shenandoah did very well in the soil without the presence of cinereus, Dr. Jaeger concluded that cinereus was competitively superior to shenandoah in the soil outside the talus. There is considerable evidence to indicate that food may be the limiting resource for which the two species are competing. Immediately after a rain, these salamanders emerge from their burrows and find food in the form of small insects and other forest floor inhabiting invertebrates to be very abundant. Because of their susceptibility to desiccation, these animals are not able to come out to feed on dry nights, so food may be regularly in short supply. It is interesting that the largest shenandoah, being so much bigger than adult cinereus, are able to survive in the woods outside the talus by eating larger food items than cinereus can consume, but presumably their young are not able to compete successfully with cinereus and are never found more than a few feet from the talus habitat.

It would appear, then, that shenandoah is a formerly widespread species that has been displaced by a more modern and efficient competitor. It survives only in a suboptimal habitat that is periodically too dry for cinereus because of its better ability to withstand desiccation. But the future is probably bleak for shenandoah because as the talus erodes more and more soil is produced and cinereus is at present entering into these pockets of moist soil and will presumably displace shenandoah and eventually cause its extinction.

HISTORY OF BOTANICAL RESEARCH IN SHENANDOAH NATIONAL PARK

Peter M. Mazzeo*

It is always a pleasure to return home, as it were, to Shenandoah National Park. I had the distinct pleasure of working here for three seasons, while a student in college and shortly thereafter. So it's nice to be home again and especially here at Skyland, the heart of Shenandoah National Park.

When I first came to the park area in 1962, I was interested in the vegetation of the area. No one before that time had done a serious study, except for the various checklists and supplements that had been prepared. So I began a rather intensive study of the vascular vegetation in the park, and tried to supplement what was already known. My remarks are based primarily on a history of the botanical collecting undertaken before that time and an up-date based on subsequent research.

Although Shenandoah National Park will be only forty years old on July third, the eve of our nation's Bicentennial, most of the botanical study that has been done in this area dates back to around the turn of the twentieth century. Very little is known about the botany of the area before that time. There is one indication going back to the very early 1800's which is somewhat interesting and perhaps explains in part the reason for the apparent lack of interest in the botany of these mountainous areas, namely, lack of accessibility to the park area. Benjamin Smith Barton, a Philadelphia physician and botanist, and a good friend of Thomas Jefferson, was making a survey trip down through the Great Valley of Virginia and parts of West Virginia. In his journal dated August 26, 1802, Mr. Barton wrote the following: "Between four and five o'clock in the afternoon, I left Hays and passed

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through the gap in the mountains called Rock Fish Gap. I observed nothing very remarkable on the way. On the mountain, I observed some of the same kind of red earth so common in the area in which I had just left, [referring to the Triassic soils of the piedmont plateau area]. Near the summit of the mountain, there is a tavern. But I thought it proper to proceed on my journey. I readily discerned that the descent on the western or rather northwestern side of the mountain is much less considerable than the ascent on the east or southeast side [of the mountain]." As time went on, roads were built through the area, but, for whatever reason, botanical studies were not made until the present century.

The first apparent collections of any consequence date to 1901, and were made by Edward S. Steele and his wife, who were visitors to Stony Man Camp here at Skyland. The early Stony Man Camp was one of the main drawing cards to the Blue Ridge Mountains, one of the first beloved areas, as it were. It is interesting to note that of all the taxonomy collected, that is, all the various species that were collected and documented with herbarium specimens by Steele in 1901 from the vicinity of Stony Man Mountain, all but one have been relocated today in basically the same area. A notable exception is the bearberry, Arctostaphylos uva-ursi, which is not only rare in this part of the country but has not been seen, to the best of my knowledge, since 1901 when it was collected at an altitude of 3600 feet on Stony Man Mountain. I know that Mr. Stevens has been looking for it, and hopefully this plant may be rediscovered in the park.

Two other botanists, William Palmer and W.H. King, both of the Smithsonian Institution in Washington, made collections in the period of 1901, 2, 3, 4, 5, and thereabouts. The next major collections that we encounter in the park were made by Iver Tidestrom, a botanist with the U.S.D.A. in Washington. Many of his collections date back to 1912, 1913-14, again primarily in the vicinity of Stony Man Mountain.

In the nineteen twenties Edgar T. Wherry, at that time a geologist with U.S.D.A., made extensive collections in the Blue Ridge Mountains. Dr. Wherry is probably more familiar to many of us for his work with phlox. He is the author of a monograph on the genus Phlox that today is the standard reference work for that plant group. Most of his collections are located in herbaria either in Washington or Philadelphia, where he later became a professor at the University of Pennsylvania. Dr. Wherry was also very helpful to me when I was preparing my book on the ferns of Shenandoah National Park.

P.L. Ricker, the president of the Wildflower Preservation Society in Washington, made extensive collections in the

Blue Ridge Mountains in the '20s and for many years thereafter. He was very instrumental in locating some of the rather unusual plants found growing in the vicinity. There are other botanists from the Washington area, others from Baltimore and Philadelphia, who made collections to document the flora of the park at that time.

The main intensive collecting period began in the 1930's, primarily in conjunction with the establishment of the National Park in this part of the eastern United States. We find many notable botanists collecting at that time, including F. Raymond Fosberg and Egbert H. Walker, both botanists in the Washington area. They made intensive field studies, documented the flora with herbarium specimens, and catalogued over eight hundred species which they published in the first major listing of vascular flora of the park area, entitled the "Preliminary Check List of Plants of the Shenandoah National Park," in 1941. The very first publication dealing with the flora of the park, however, was published in 1935. This was not about the vascular plants but rather the fungi found growing in the area. It was published by John Stevenson, a curator in the National Fungus Collections of the U.S.D.A. in Beltsville, Maryland.

During this period, W.H. Camp of the New York Botanical Garden, who was especially interested in the Ericaceae, the Heath family, made numerous collections in the area. He identified many hybrid forms growing in the park. As many of you probably know, it is not always easy to identify distinct species of the park's blueberries because of the hybrid forms found there.

E.H. Fulling, also of the New York Botanical Garden, did extensive collecting in the area during the mid-1930's. In 1936, he published a paper on a new variety of Balsam fir named Abies intermedia, the Blue Ridge Fir. It is rather unusual to find this particular variety so far south in the Blue Ridge Mountains, or the Southern Appalachian Mountains, but here it is on Stony Man Mountain, the Crescent Rocks area, and Hawksbill. A few years earlier, M.L. Fernald of Harvard University had described a very similar plant from New England, and later Abies intermedia was reclassified and grouped in with Abies balsamea variety phanerolepsis.

Dr. Ruskin Freer, a professor of botany at Lynchburg College, made extensive collections in the area of southern Shenandoah National Park between Rockfish Gap and the Roanoke area. On various occasions he would come up and meet with botanists collecting in what is now the park. His work has been instrumental in furnishing a history of botanical collections and research in the park.

Arther H. Leeds and Frances Harper, both of Philadelphia, also made many collections important to the documentation of the park's flora. J.E. Benedict, Jr., a seed tester from the Washington area, made valuable collections. I understand his private herbarium was recently acquired by V.P.I. and S.U. at Blacksburg.

All of the various plant species that had been collected and documented with herbarium specimens to prove the existence of these various taxa from the park area, were catalogued and published in 1941 in the "Preliminary Check List of Plants" by Fosberg and Walker.

The National Park was established and dedicated in 1936: the Skyline Drive and Appalachian Trail system were constructed, providing access to the "backbone" of the Blue Ridge Mountains. Accordingly, many more botanists became interested in the area.

During the early 1940's an Englishman by the name of E.K. Balls, who was in the Washington area with the War Department, made extensive collections, primarily on Old Rag Mountain. This was the first major botanical "expedition" to the Old Rag area. Mr. Balls produced several new records for the park flora.

H.A. Allard, another U.S.D.A. botanist from Washington, was interested in the flora of the northern part of Virginia and made extensive studies in the Bull Run Mountain area, as well as the Blue Ridge and various other places in northern Virginia and northern West Virginia. O.M. Freeman of the U.S.D.A. also collected quite a bit in the Blue Ridge Mountains. Dr. F. Ewan of Tulane University made various collections near the Washington area. E. Graff, Assistant Secretary of the Smithsonian Institution, collected in the park. Fred J. Hermann, perhaps the most knowledgeable botanist on the genus Carex, the sedges, made and identified numerous collections. E.P. Killip of the Smithsonian Institution and Warren H. Wagner, Jr., at that time a graduate student, but now a professor at the University of Michigan, collected in the Blue Ridge Mountains. (Dr. Wagner is most notably known for his work on the ferns.) Frances W. Hunnewell of Wellesley, Massachusetts, also made many collections in the Blue Ridge Mountains, including some in Shenandoah National Park.

There is a very good story to mention at this time. If you browse through Gray's Manual of Botany, you will see listed in there Diervilla sessilifolia, which is a species commonly found in the southern Appalachian Mountains. When Mr. Hunnewell made a collection from Warren County, Virginia,

along the Skyline Drive, it was cited in the eighth edition of Gray's Manual of Botany as being a rather disjunct population. Fortunately, he had made a herbarium specimen. Some botanist later questioned the validity of that disjunct record from Warren County, and when the specimen was scrutinized by other botanists it was decided that the plant was not really Diervilla sessilifolia, but rather Diervilla lomicera, a species that is common in the Shenandoah National Park and other mountain regions of eastern North America. This is a good illustration of the importance of specimens for documentation of botanical research.

Fosberg and Walker published the first supplement to their "Preliminary Check List" in 1943. Meantime, members of the park staff began studying the area's vegetation: W.D. Chick, a park naturalist, a park forester named Moore, and Griffing, the landscape architect. Unfortunately many of their plant catalogs were not documented with herbarium specimens but only were named in the park Check List. Now we are not sure if some of those taxa are correctly represented in the park or not. In 1948 Fosberg and Walker published a second supplement to the Check List.

One notable plant that had been discovered in the southern section of the park was Xerophyllum asphodeloides, the turkey beard, a member of the Lily family. It's a rather unusual plant, common in the New Jersey Pine Barrens, found here on some of the mountains in the southern section of the park. It is rather curious that this plant should be in that area. I've been there to look for it myself a couple of times and have never yet seen it in flower. I've seen the plant growing there with a persisting inflorescence, the flower cluster and stalk from a previous year. The plant apparently blossoms every other year, so hopefully I'll get a chance to see it in flower and will collect it when I do.

In 1945, the first major paper and Check List on the Bryophytes of the park was published by Irma Schnoberger and Frances E. Wayne, both from the University of Michigan. This is the only such paper on this section of the plant kingdom.

Botanists continued to collect in the area during the 1950's, and, in 1955, a third supplement to Fosberg and Walker's "Check List" appeared. In 1959, Fosberg published a fourth paper entitled "Notes on the Park Flora."

The first major publication involving a group of vascular flowering plants in the park was published in 1958 by Grant and Winona Sharpe entitled 101 Wildflowers of Shenandoah National Park, a very handy small guide book to the more common wildflowers in the area. Unfortunately this book is

now out of print. This book was one in a series the authors have prepared for various national parks such as Shenandoah, Mt. Ranier, and other national parks in the western part of the country. The Sharpes are associated with the University of Washington in Seattle.

During the 1960's, more and more people became interested in the flora of the park and we find for the first time a major interest developing among amateur botanists. Many people, with permission, collected specimens or took photographs that provided or documented park records. These include Virginia Phelps, of Pittsburgh; Henry Heatwole, a park collaborator, who is with us today; Hugh Crandall; Charles E. Stevens of Charlottesville, Virginia, also with us today; and many seasonal park employees - there are several, so unfortunately I won't cite each one by name. Their contributions have been significant, particularly in documenting more remote areas of the park, and their records have provided valuable supplements to the check list of the park flora.

In the 1960's, other publications about the plant life in the park became available. Most notably, in 1965 Arthur Stupka published his Wildflowers in Color, a "tri-Park" book. It is a superb publication with very good kodachrome reproductions of the wildflowers growing in Shenandoah National Park, the Blue Ridge Parkway and the Great Smoky Mountains National Park. For the first time we had a comprehensive or much larger publication dealing with the wildflowers, perhaps the vegetation most attractive to many of the park visitors.

In 1965 Fosberg and I published yet another supplement to the park's Check List, adding to the record a more detailed study than had yet been done of genera such as the genus Tilia, the basswoods, a rather complex genus found growing naturally throughout most of eastern North America. As many as four different taxa or species had been described for this genus in the park. However, a recent monograph helps to explain some of the floristic problems. We now think there's actually just one species growing in the park area [which means I must update Trees of Shenandoah National Park]. The genus Crataegus, hawthorns, also has been given some attention, but it remains a problem group despite our best efforts.

When I joined the staff of the Shenandoah National Park I continued my collections there. A period at the National Arboretum in Washington engendered an interest in cultivated plants, or plants persisting from cultivation, in areas like the park. Many of these I had documented during the years I worked here as a ranger-naturalist. In 1966, I published

a small paper on many of the ornamentals, both woody and non-woody, found growing or persisting at old homesites in the park area. One superb place to locate exotic ornamentals is near the old Judd property at Skyland. There are more exotics persisting there than any place else in the park.

In 1967, I published another supplement to the "Check List" of park plants, and in 1968, I published a book dealing with the identification of the trees of Shenandoah National Park. Subsequently, more species have been identified and I think the book is ready for updating.

A further supplement to the Check List was published in 1972. The total known number of species in the park was then just under 1200. We have actually catalogued 1195 taxa used to include species, sub-species, etc. for the park area. In 1972, I also published or prepared the book on ferns and the fern allies of the park as proposed by the Natural History Association. This was the first major treatment given to that interesting group of vascular plants.

What is going to happen in the future? Hopefully botanists, both professional and amateur, will continue to study in the park and to document and publish their findings. I feel strongly that one's knowledge of the flora is critical to any other research involving the park vegetation. Mr. Stephens is going to publish another supplement to the Check List, setting many new records. This will be in print in the next year or so. Dr. Fosberg, who unfortunately could not be here today, has for some years now been trying to correlate the original Check List and all of the supplements into one document, annotated with habitat data. I have been working on a supplemental list myself with assistance from Mr. Peterson, an amateur botanist from the Washington area who has spent hours in the park each year looking for some rather unusual plants and trying to fully document each of the park taxa. Individuals like Dr. Fisher are doing their research on some of the various species found specifically at old homesites in the area.

There are undoubtedly other people who have been collecting, floristically speaking, data from the park area, many of whom are unknown to me. But hopefully through meetings such as this we can exchange ideas and information which increase our awareness of the park vegetation. Some day we might have a complete list of these plants, if indeed it is possible to do such a project in view of the fact that there are always some plants moving in or moving out of the area. Some botanists say they like to study plants and collect plants because they don't move around like insects. Some species

do migrate; they don't have limbs or legs, but they certainly do migrate into and out of areas, and for this reason the flora of the park will probably never be 100% completely known.

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BLACK BEARS

Jack W. Raybourne*

I'd like to brief you, if I may, a little bit on the work we're conducting in Virginia on the black bear. It's an animal that is quite controversial, to say the least. It's an animal also that is very, very difficult to get much good information on. Our aim in the study is to establish biological bases on which to manage Virginia's bear population. There are different avenues of enjoyment for different individuals and we're going to try to come up with some ideas that will help not only the hunting public that I work for but also the visitor who enjoys seeing these animals, as all of us do.

Our study of the black bear is state-wide in scope and includes lands here on the Shenandoah National Park where we find about 25%, roughly, of the state-wide black bear population as we currently know it. Other prime study areas are the United States Forest Service lands, Virginia Game Commission lands and selected private lands in the Commonwealth. The Shenandoah National Park serves as the primary control area, if you will, for the studies that we are doing. It is the largest single block of "non-hunted" land that we have available in the state. It gives us a good "control" from the standpoint that it shows us what we should expect in terms of population phenomena: births, deaths, and movements which should occur in a non-hunted area. We do know that this area is illegally hunted, regardless of how we might want to think of it. The periphery, of course, can be legally hunted. It's a large area; manpower is limited and certain types of individuals will take advantage of the situation. Still, it serves as the best available control area for our study.

We are trying to establish an age and sex structure on the bear population similar to what a life insurance company

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does with humans. From this we can predict, based on the production rates, and the mortality factors (not only hunting but accidental causes of death, disease, and what have you) that occur in a population. Reproductive factors are highly important in black bears since they are so unusual in their biology. They are "induced ovulators" and "delayed implanters." The former "fifty-cent words" meaning they shed their ova during the physical act of mating, as do rabbits. They are also delayed implanters like the weasel and mink family. The fertilized ovum implants at some later point in the gestation period. In the case of bear, which normally breed June-August, the fertilized ovum divided into two, then four, eight, sixteen cells to a blastula stage. It then free floats in the uterus until about mid-December at which time light conditions are such that it implants into the wall of the uterus and begins a very rapid development. The young are born in late January or early February. The black bear has both of two conditions that are very unusual in the animal kingdom. In addition they only breed every other year and don't reach normal maturity until three years of age.

We have two studies in progress designed to improve our overall knowledge of this fine animal. I think about the best way to show you what we're doing is by way of photographs. I'll describe a bit of the work we're doing, what we hope to accomplish and some of what we've found out to date. We have one more year ahead of us of actual trapping, tagging-type work. The primary thing that we're after is a small premolar tooth with which we can establish a bear's age.

The Game Commission, National Park Service, and the U.S. Forest Service have collaborated in this study of the black bear. The problems associated with such an investigation, though great, have fortunately now been overcome to a large extent. The first problem primarily concerned terrain. Bears live in typically remote, inaccessible, very rugged terrain that creates problems for researchers in getting equipment into the study area. Additionally, because of their low production potential, bears simply do not provide as great numbers of animals to study as do deer, turkeys, squirrels, etc. Compounding these two problems has been a means of handling bears in a manner safe to the operator and the animal itself. We now have tools available to us that will allow us to do this.

There is a Southeastern Association of Game and Fish Commissioners which some of you may be familiar with. I am a member of the Black Bear Sub-Committee under this organization which is coordinating various research studies designed to maximize several phases of bear research simultaneously.

We have divided the "puzzle" so that each researcher is working on a separate "piece" of the unknown. It is planned that this knowledge be pooled so we can put the puzzle together as quickly as possible. Each state or set of states has a different problem such as reproduction, home range, habitat, determination of age and sex structures, etc. We're trying to gain as much as we can as quickly as we can on this animal now that we have the tools available.

Bears can do a considerable amount of damage. They are a very powerful animal. There's nothing quite like coming back and finding a convertible, with the top destroyed, "easy pickings" for a bear, in which someone has left food items. This becomes a real problem for the park and also for the visitor who is unfortunate enough to have left something in his car which is attractive to a bear.

I want to point out that of the many bears we've trapped in this park, only about 10% have been known to frequent campgrounds at all. The other 90% are free-roaming, free-ranging wild black bears that stay in back country areas. Fortunately, the Shenandoah has not had, to my knowledge, the "panhandling bear" evident in the Great Smoky Mountain National Park.

Bears cause some crop and property damage to adjacent land owners. This occurs primarily to corn from July to September when corn is in the tender milk stage. The natural fruits and berries are gone and, at this point, nuts, acorns, etc. have not yet fallen. Fresh corn is attractive, to say the least. It wouldn't be so bad if the bears' activities were confined to eating, but they destroy a lot while fighting, wrestling, etc., especially the young males. We've observed bears literally riding down a row of corn, allowing those big stalks to run across the chest. It evidently feels good! We caught fourteen bears in one farmer's corn field in a week's time. They can destroy a tenth of an acre in one night. If a farmer has a corn patch in a small open field that's rocky, mediocre farm land to begin with, it's all he's got; and if it's right next to "Bear Heaven," he's got a problem! Fortunately we've been able to take care of many of these landowner complaints. We trap and relocate problem animals to a new habitat in western areas of the state with the hope of "rehabilitating" them. A percentage of them do return.

Black bears are such creatures of habit that instead of making evenly-depressed trails they form little pads or depressions that are rather obvious in heavily-used bear country. Where you don't have deer in the area you can see this fairly readily. Each bear travelling the trail steps in the footprints of its predecessor until obvious depressions

result. This habit is a "natural" for using a new type of trap known as the Aldrich Foot Snare. Previously, when anyone mentioned bear traps the listener thought of powerful steel traps that were extrememly dangerous. The Aldrich Foot Snare is a very safe, humane trap. A small child can step into one of these and get out of it just by simply loosening the noose. It will hold the animal in place until we get there with a dart gun. We simply dig up one of the depressions on a bear trail and set the snare noose, made of 42 inch aircraft cable with 4,200 pounds of tensile strength. We also can use baited sets with this type trap. The simplest baited set consists of two small anchor trees, four to six inches in diameter, about two feet apart. Then we build a closed "horseshoe" out of small saplings about four feet deep, with the two small trees serving as the mouth of the horseshoe. The set is then baited. They'll come around the open end. Black bears have very soft, sensitive pads on the bottoms of their feet. They won't step on anything sharp, such as a stone or a stick, that they can avoid. By strategically placing stepping stones and sticks, we can direct his feet into the area of the snare trigger.

The culvert trap is used exclusively in the Shenandoah National Park since there is less danger to the public when the bear is in this type of trap. They are marked very clearly so that anyone knows that it is a bear trap. The culvert trap is potentially more dangerous to people than the snare, particularly if small children were to be playing around it. The door weighs about 50 pounds. We visit these traps daily. They weigh approximately 500 pounds empty. With a device that heavy, plus a bear that may weigh as much, handling of traps was formerly a problem. To solve this we strengthened the truck's tail gate, attached a cargo roller track, and added an electric boat winch. The winch has been absolutely indispensable to us. We use it for all loading of traps and weighing of animals.

The new drug which we have available to us now is known as M-99 Etorphine. It's a synthetic morphine compound and is extremely powerful and has an antagonist that works with it. It generally takes effect in 15 minutes, making the animal "high as a kite." The animal's respiration rate drops dramatically, but the heart rate remains esentially stable, about one beat per second. We don't attempt to handle the animals now until the respiration rate drops to about one inspiration per twenty seconds. Normally they pant very quickly, like a dog.

There are two different kinds of injecting devices, one for liquids and one for solids. The drugs currently in use come in liquid form. The drug formerly used was known

as Sucostrin (Succinylcholine Chloride). It is a skeletal muscle immobilizer which was pre-assembled in disposable darts with excellent shelf-life in the dry form. It can be kept almost indefinitely, pre-loaded. Unfortunately, in the case of an accidental human injection or bear overdose there is no antagonist for Sucostrin except oxygen. With the dosage required to immobilize a black bear, accidental injection would probably mean certain death for a human.

To my knowledge, the drug that we are now using has not been tested on humans. Injection is done at point blank range with a CO₂ dart pistol. Within 15 minutes, normally, the bear is sufficiently anesthetized to handle. The first thing we do is to weigh each animal and affix a numbered metal tag in each ear. Each tag has a reward inscription to encourage individuals to report any dead bears to our agency. This gives us an opportunity to monitor bear mortality and survival on a sample basis by sex, age, time of year, etc. Tag data also provides information on weight gain and movements.

We collect a variety of measurements on these animals once we've got them in hand. Some information collected is not needed presently, but is collected with the possibility of future use. Various head measurements are taken along with total body length, shoulder height, heart girth and measurement of the front and rear pads. There appears to be a degree of correlation between heart girth and weight by sex.

Gerald Blank is a trapping specialist with our agency. He's been instrumental in developing a lot of the techniques that we utilize not only on black bears but for live trapping other species as well.

We take an extra step to permanently identify individual bears in addition to ear tagging. Some studies in other states have indicated that one or both ear tags may be lost the first year, particularly by the males, due to fighting, greater movement, etc. We tattoo the lowest ear tag number inside the upper lip as a permanent means of identification.

The primary thing that we're after is an age and sex structure on the population. Establishing an accurate age has been the biggest problem that has beset black bear researchers. Turkey, deer, and many other species can be aged very accurately. Age and sex data along with reproduction data has allowed us to manage deer populations to numbers far greater than the Pilgrims found when they came to this country. Current statewide deer harvests exceed 66,000 animals due largely to planned management on a sustained-yield basis. We've not been able to do this with black bear because of past diffi-

culties in aging. We formerly could call a bear a cub, possibly a yearling or an adult. "An adult" is a broad category. Age of adults is important because of its bearing on reproduction, particularly in the case of the female. Therefore, we need to have an age and sex structure.

There is a new technique that now enables us to get within one year of a black bear's age. The technique involves examination of cross-sections of tooth samples. We pull a small premolar, just alongside the large canine in the upper jaw, from animals that we trap. Additionally, the hunters in the state who are successful in harvesting a black bear return to us voluntarily a front portion of the lower jaw from which we extract the large canines and do a cross-section on that to see the cementum annuli that lie within. The principle is almost exactly the same as involved in tree growth. During the spring and summer, when vegetation is lush and nutrition is at its highest, there is active depositing of bone and tooth cells. This depositing slows off during the winter months, resulting in alternate layers annuli which can be observed and counted under the microscope. The first upper premolars lie immediately behind the large canines. Dental forceps were used for initial premolar extractions, but were discontinued in favor of a standard 8-inch screwdriver. Professionally, this may sound crude, but it's the best tool we've found yet. The matchhead size tooth lies immediately adjacent to the large canine. By inserting the blade of the screwdriver between the two and twisting, the tiny tooth will roll out of its socket with little resulting gum damage. Removal of an upper premolar provides good drainage and we have found that an oral antiseptic is not necessary.

This photograph of an unprocessed canine tooth cross-section (see Figure 1, page 34) will give you a rough idea of what we are looking for. This is just a very rough cross-section, polished just a little bit. The area on the extreme left, the white band, is the enamel portion of the tooth. The next layer containing the cementum layers that we're after. The innermost region is the root canal, which closes in with age.

The tooth samples are put in a formic acid solution for about a week. This de-calcifies or removes all the enamel on the tooth leaving it soft and pliable, almost rubbery. It is then placed in a paraffin bed and a freezing microtome is used to section it to about 5 microns which is then mounted on a slide to go through a stain, alcohol and washing procedure. You end up with something like this (see Figure 2, page 34). This particular photograph is not a photomicrograph, but does show the presence of the annuli. The enamel has been removed by the acid. The area on the extreme left



FIGURE 1. Unprocessed canine tooth cross-section.



FIGURE 2. Processed canine tooth cross-section, annular rings visible on the extreme left hand margin

hand margin of this photograph of the tooth section is the dentine. Within it you can see the annuli. On this photograph you can count most, but not all of the annuli which tend to be compacted in older animals. Under the microscope the annuli can be separated. This particular animal was a 19-3/4 year-old male that was killed in Rockbridge County in 1973. It was killed on the Game Commission's Goshen-Little North Mountain Wildlife Management Area. The oldest specimen we've had, a 20-3/4 year-old female, was also obtained from one of our hunting areas. She had been tagged originally on the Big Levels area of Augusta County in 1958 and was estimated to be 2-1/2 years-old when captured. Interestingly, she was killed within 1/4 mile of the original trap site. The oldest animal that we have trapped to date was a 16-3/4 year-old male weighing 360 lbs. trapped here in the park in 1975. It was not the largest animal trapped. Weights of bears handled have varied from 8 pounds to a known 580. We've had two males exceed our earlier 600-lb. scale capacity. Drug dosages indicated weights for these two animals of 705 lbs. and 750 lbs. for the 7-1/4 year-old and 10-1/4 year-old bears respectively. We have since acquired a friction tensiometer with capabilities of $\pm 1\%$ accuracy up to 1,000 lbs. Unfortunately, we've not been able to recapture either of those two animals to document their true weights.

Following processing, the antagonist for the original drug (M50-50 Diprenorphine) is injected directly into the femoral artery. The animals are normally "up and running" within 1-3 minutes. Subcutaneous or intra-muscular injections may require 20-45 minutes for recovery. We have a number of visitors along occasionally. The recovery phase is always a bit dramatic for them. We have a standard "three-minute rule" now. If the bear hasn't recovered within three minutes, our guest gets to walk up to the bear and shake him with his foot!

One of the first signs of initial recovery is the rapid return of the respiration rate to normal "panting." This is followed by twitching movements of the ears while the animal lies quietly. Once this stage is reached, any sudden noise will generally bring them up at a run. We have yet to have the first aggressive response following recovery from any of the nearly 500 animals handled. Their natural reaction is to instinctively retreat to the nearest cover available.

I'd like to introduce some of the data we've compiled thus far. For bears trapped and harvested from 1972 to 1974, the average age for the harvest sample was 4.2 years for males, 5.83 years for females and 4.83 years for combined sexes. The harvest sample doesn't differ greatly from the trapping sample. The average age for the trapping sample was 3.54

years for males, 6.19 years for females and 4.62 years for combined sexes. Female survival appears greater in both samples, especially the trapping sample.

A comparison of age and sex structures of both samples indicates certain similarities. Both harvest and trapping samples are composed primarily of younger age (1-3 year-old) male bears. Females predominate in the older age classes in both samples.

We get a striking contrast when we examine the population structure of the bears that have been tagged and subsequently harvested, poached or accidentally killed by vehicles. No females appear in this sample beyond 6 years of age! The great majority of these bears were trapped in the park and subsequently harvested in close association with the park. The data imply that the female segment of the population receives a large degree of protection by virtue of the size and security of preserved lands. Females appear to be "home bodies," occupying a relatively small home range of 1-10 square miles; whereas males may use from 10-100 square miles. The greater range of the male frequently carries him away from the protection of the park to areas where he may be harvested.

We examined the proportion of the tagged bears harvested annually as a means of estimating the proportion of the total population harvested annually. We have tagged 231 bears from 1972 to 1975. Eighty-four (84) tagged bears are known to have been removed from the population to date. (36.4%). Fifty-six (56) of the 231 tagged bears were recovered the first fall following tagging (avg. 24%). Mortality figures are minimum known reported kills. Unreported illegal hunting no doubt has removed additional tagged animals from the populations.

In four years, 9 of the 12 animals trapped and tagged in 1972 are gone from the population (75%). In 1973, we trapped and tagged 97 bears in the Shenandoah National Park. Thirty-two and nine tenths percent (32.9%) were harvested the first year. Not all this was legal. In 1974, an additional 9% were removed. An additional 5% was removed in 1975. The total to date removed from the population in a three-year period is almost 50%. Average mortality for the three trapping periods provide at least two years recovery data indicating that 43.9% of the tagged population is gone within a two-year period. Since the majority of the tagged bear mortality is closely associated with the park, the observed mortality should be considered a minimum when applied to hunting lands.

We have added tremendously to our knowledge of the black bear in a very short time. In addition to age and sex structure data, we are obtaining new knowledge on the handling of nuisance bears, movements, home ranges, reproduction and mortality. We wish to extend our thanks to the personnel of the Shenandoah National Park for their kind assistance and for allowing us to use this area for intensive study of this fine animal.

STATUS OF KNOWLEDGE OF THE GEOLOGY
OF SHENANDOAH NATIONAL PARK

John C. Reed, Jr.*

I will talk a little about the status of our knowledge of the geology in the park and surrounding regions, but perhaps it is appropriate to start with a couple of remarks about research in the national parks in general. It seems to me that there are three general types of research that go on in the parks.

The first type is research which is directly related in some way to the management, regulation, development or interpretation of a park. For example, the studies of the burns on Big Meadows have a bearing on management. Studies of the geology related to the location of ground water resources for camp-grounds have a bearing on development.

A second kind undertaken here because the park provides a controlled setting necessary for that particular type of research, would generally be biological research of one kind or another where you need a protected population or a protected ecological situation.

The third type of research is undertaken not because it's a park area, but because the park is just part of the general area of study. Most geologic studies fall in the latter category. Obviously, studies of geology do play a part in the interpretive program in a park and in a few cases play a part in the management and development plans. But by and large in geology we make the studies because the park is part of the broader area of interest.

So let's now take a look at where Shenandoah fits into the geology of this part of the country. There are obvious differences in the landscape and physiography of the different

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parts of this region: the Blue Ridge, the Great Valley, the Valley and Ridge Province, the Appalachian Plateau to the west, the Piedmont Plateau and the Atlantic Coastal Plain with the great estuaries formed by drowned rivers such as Chesapeake Bay.

Starting with the Blue Ridge, we have a great upfold in the core of which are exposed ancient granite gneisses. These are flanked by a series of greenstones and sedimentary rocks known as the Catoctin Formation which are well described in the literature of the park. This whole unit is one great upfold, so that the rocks on the west side continue right around the nose to appear again on the east side.

West of the Blue Ridge are the thick sequences of folded limestones, shales, and sandstones that underlie the Valley and Ridge Province. The layers of sandstone resist erosion and stand out to form ridges. The limestone and shale layers form the valleys. These long continuous ridges and intervening valleys are obvious on a satellite photograph of the region.

East of the Blue Ridge is the Piedmont Plateau, underlain by a complex series of metamorphosed and highly contorted rocks that originally were sedimentary and volcanic rocks but which are now so highly altered and deformed that their original character is difficult to decipher. Chiefly these are schists and gneisses but in a few places there are downfolds of less metamorphosed rocks, which occasionally contain fossils. Some of these fossils are of the same age as the fossils contained in some of the unmetamorphosed sedimentary rocks west of the Blue Ridge.

East of the Piedmont Plateau is the wide expanse of the Atlantic Coastal Plain, underlain by layers of soft sand and clay that form a wedge that thickens seaward and actually extends hundreds of miles offshore. It is the offshore part of this wedge that may contain oil and gas deposits on the Atlantic Continental Shelf.

One other unit that I neglected to point out to you before is a series of basins just east of the Blue Ridge and in general separating the Blue Ridge from the Piedmont. These basins contain sedimentary rocks that are older than those of the Coastal Plain, but much younger than those of the Valley and Ridge, Blue Ridge, or Piedmont. These are the red sandstones and shales that underlie the area between Culpeper and Manassas. Locally these rocks contain tracks of dinosaurs. The basins characteristically are bounded by faults on one side and by an erosional contact on the other.

This gives you a rough feeling of the variety of geology

with which we deal and a general idea of where these various rock types are found. But what I really was supposed to talk about is the status of our knowledge of the geology. I think perhaps the most profitable way to do this is to talk about the advances in our knowledge over the last fifteen or twenty years.

The general outline of the geologic framework I have described was well known by the 1930's. Studies had gone on in the park area as early as 1880 and by 1930 we knew the basic outline. But in the past forty years, there have been three major advances in the knowledge of geology as a whole and the eastern United States in particular.

The first of these advances is the detailed knowledge of rock locations and arrangements gained as a result of hard work by survey parties and mapping teams. A geologic map of Virginia was published in 1958. Since the publication of that map, detailed geologic mapping has proceeded to a point where the entire area of Shenandoah National Park has been mapped at a scale of one inch to a mile. I understand that this map will be published by the Virginia Division of Mineral Resources by mid-summer. At the same time, geologic mapping has been going on in a number of other areas: in the northern part of the Blue Ridge, in the area between Quantico and Fredericksburg, in the Richmond area, and elsewhere in the Blue Ridge, Piedmont, and Valley and Ridge. These studies have been under the auspices of the Virginia Division of Mineral Resources, the U.S. Geological Survey, and a number of colleges and universities.

In conjunction with the geologic mapping we have begun to learn a great deal more about the origin of various rock types and about the relations of one group of rocks to another. For example, during the early mapping the origin of the greenstone here in the Blue Ridge was not understood. Since that time, it has been well established that the greenstones were lavas. We can now talk about what kind of lavas they were and under what sort of conditions they were erupted. Similarly, sizable bodies of rocks in the Piedmont that were previously thought to have been of igneous origin--granites of some kind or another--have now been proven to be deposits formed by vast chaotic submarine slides, subsequently metamorphosed and uplifted, and now in a state that is difficult to distinguish from igneous rocks. Once we understand the origin of such rocks we can better comprehend the geologic history of the region.

One of the most difficult problems the early geologists faced was trying to discover the relationship between the sedimentary rocks west of the Blue Ridge and the metamorphosed

rocks east of the Blue Ridge--in other words, the relationship between the rocks of the Valley and Ridge Province and the rocks of the Piedmont Province. The reason this has been so difficult to establish is that throughout most of this part of the Appalachian Mountains, the Triassic basins separate the Blue Ridge and the Piedmont, and there is no way to trace one group of rocks into another. But within the last decade, the relations have become pretty well established by detailed studies of the arrangement of the rocks and the structures that they contain. Careful field studies of this kind represent one of the major fronts on which geologic knowledge has advanced.

Another major advance in our knowledge, one that is equally important, has been the development of ways of determining the absolute ages of rocks and minerals. Up until about 1950, geologists could generally determine that one rock body was older or younger than another nearby body. We could determine that one rock stratum containing fossils was older, younger, or equivalent in age to another fossiliferous rock stratum in some other part of the world by studying the fossils, but we had no way of establishing the absolute age of the rocks. The techniques of geochronology, or determining absolute ages using the decay rates of natural radioactive isotopes, have become some of the most powerful geologic tools that have evolved in the last few decades.

Let me describe some of the results of these dating studies. The accepted figure for the age of the earth is now in the neighborhood of 4.5 billion years. This, incidentally, is about the age of the oldest rocks returned from the moon. If we take a standard yardstick and let it represent the age of the earth, a billion years is equivalent to about eight inches. The major geologic eras are the Paleozoic, the Mesozoic, and the Cenozoic. The first well organized fossils on which our fossil time scale depends appears about 550 million years ago. Thus most of the rocks that we are able to date up until the advent of geochronology occupied only the last 5 inches of the yardstick of geologic time. The time since the origin of man represents only about the last 1/50th of an inch of that yardstick!

In order to illustrate the vastness of geologic time that modern geochronology has established, let me ask you to imagine walking backwards in time at the rate of about one step a year. It would take you about 115 steps, or slightly less than the length of a football field, to get back to the time of the Civil War. One and a third football fields would take you to the time of the Revolution; and you'd have walked a quarter of a mile to get back to the time of Columbus. You'd have walked somewhat less than five miles to get back to the

building of the Pyramids of Egypt and about 1000 miles to get back to the time of the first man. To get back to the beginning of the Mesozoic Era, the age of the dinosaurs, you'd have walked 65,000 miles, or $2\frac{1}{2}$ times around the world. In order to get back to the age of the earth, you'd have walked $4\frac{1}{2}$ times the distance to the moon.

When we consider the geology of Shenandoah, we find that the granites and gneisses that make up the core of the Blue Ridge range in age from about 1 billion years to about 1.1 billion years. The lavas of the Catoctin Formation now are thought to have an age of about 820 million years. This age is not precisely determined but it's the best information we have at the moment. As we go south in the Blue Ridge, we find vast thicknesses of rocks of approximately similar age. The Great Smoky Mountains are underlain by tens of thousands of feet of sedimentary rock the age of which is believed to be about equivalent to the age of the Catoctin lavas here.

The next younger group of rocks exposed in the park are the basal beds of the sequence of sedimentary rocks of the Valley and Ridge Province. These are the quartzites and shales of the Chilhowee Group, that are found in a few places on the crest of the Blue Ridge, but which crop out almost continuously along the west foot of the Blue Ridge. They have an age of just a little bit more than half a billion years, about 550 million years.

The younger sedimentary rocks of the Valley and Ridge Province form a continuous sequence that goes upward in age to about 250 million years.

Rocks in the Triassic basins east of the Blue Ridge range in age from about 180 to 190 million years, and the strata of the Atlantic Coastal Plain have an age of about 80 million years going up almost to the present.

Lastly, we find the youngest deposits in the Blue Ridge--the talus slopes in which the salamanders live, and the other surficial deposits.

Even more impressive than the length of time that is represented by these rocks is the fact that all rocks preserved in this part of the Blue Ridge represent only about 10 percent of the time that has elapsed since formation of the earth. We must also be aware of the episodes during which the rocks were folded, faulted, and metamorphosed to form the Appalachian Mountains. These episodes climaxed about 450, 350, and 230 million years ago. This understanding of the framework of geologic time is the second main front on which the knowledge of geology has advanced in the last decade or two.

The third advance has been the development within the last fifteen years of the concept of plate tectonics. This has had an effect on the earth sciences that is just as fundamental and just as far reaching as the development of the theory of evolution was for the biological sciences.

Until the development of the plate tectonic concept, we were pretty much observing isolated facts and describing isolated phenomena without any sort of integrating model. Briefly, the idea is that the entire crust of the earth is divided into a small number of relatively rigid plates that are slowly moving with respect to one another. The plates are moving away from each other at the mid-ocean ridges such as the Mid-Atlantic Ridge and the East Pacific Rise, while the plates are converging at the ocean trenches.

Consider a mid-ocean ridge with crust moving away from it on both sides and new crust forming in the middle. The process is rather like two ice floes moving apart and new ice forming in the open water between. New crust constantly forms in the area of volcanic activity at the crest of the ridge, and becomes part of the plates moving away from the ridge. What happens when one of these plates meets a plate moving away from another ridge? What happens is that one of the plates moves down beneath the other one. The down-going plate is carried to a depth within the earth's mantle where the temperatures are high enough that the plate is melted and returned back into the mantle.

One of the rules of plate tectonics seems to be that the crust under the oceans is thinner and denser than the crust under the continents. When an oceanic plate meets a continental plate, it is the oceanic plate that turns down and is consumed. This process is described as subduction. Just to give you some of the evidence on which the theory of plate tectonics is based, we can review a world map showing the distribution of earthquake epicenters during a ten year period. The ocean ridges are marked by a very distinct line of earthquake epicenters, but most of the major earthquakes occur along the subduction zones where plates are turning down and being consumed. The pattern fits beautifully the pattern of the plate boundaries.

Again you ask, what does this have to do with the geology of Shenandoah? Well, I should digress just a minute and discuss a little bit more of the detail of what is thought to happen at one of these converging plate junctions. The oceanic plate is colliding with the edge of a continental plate and is going down. The continental material is presumably very much like that exposed in the granites and gneisses here in the Blue Ridge. As the plate goes down, the temperature

risers because of friction and some of the material at the edge of the continental plate and some of it in the down-going plate, is melted, moves upward, and erupts as of volcanoes. This forms a chain of volcanic islands, much like the Island of Japan. Earthquakes are occurring along the down-going plate and the chain of volcanoes is forming on the overriding plate above it. The rocks between are increasingly deformed and belts of folds created. This goes on until another continental plate is carried into the subduction zone. Because the continental material is lighter and thicker, it can't be subducted and when that collision occurs the subduction stops and a mountain chain is formed, with folded and faulted volcanic and sedimentary strata.

With the development of the plate tectonic concept, it became possible to begin understanding some of the fundamental causes for the formation of the Appalachian Mountains. A map showing a reassembly of the continents as they were thought to have appeared about 180 million years ago would indicate the outer edges of mountain systems which are the same age and the same structural style as the Appalachian system. Mountains similar to the Appalachians in Africa, in Newfoundland, in Ireland, Great Britain, Norway and Greenland can all be fitted into a coherent picture in which the structures and the various rock belts can be reassembled. This mountain system, which has been referred to as the Caledonide or Appalachian-Caledonide system, is thought to have originated from a collision between the African and European plates on the east, and the American plate on the west. This collision occurred during the interval from about 450 million years ago to about 250 million years ago.

At that time, the continents would have been assembled and since that time they have been spreading from the Mid-Atlantic Ridge, forming new crust until we have a situation today wherein the old mountain system fragmented--some parts (the Appalachians) in North America, other parts in Africa, Greenland, the British Isles, and Norway.

This is a very nice model of the evolution of the Appalachian Mountain system and the Atlantic Ocean starting from about 180 million years ago and going forward. But the model can also be applied going backward. The granites and gneisses that form the core of the Blue Ridge, the billion year old rocks, are presumably part of an original crustal plate that included all of North America, Europe, and Africa. This plate was ruptured about 800 million years ago and during that rupturing the lavas of the Catoclin Formation welled up in the rifts that were formed as the plate came apart. As spreading continued the first Atlantic Ocean was formed. Many of the sedimentary rocks which we now see in the Valley and Ridge

Province were deposited on the submerged edge of the North American continent as that early Atlantic opened. They were deposited on the trailing edge of the continental plate.

About 450 million years ago, for some reason, this movement reversed and the ancestral Atlantic began to close by subducting crust along the eastern edge of the American plate. During that interval, a chain of volcanic islands formed. Associated sedimentary and volcanic rocks were deposited in shallow seas behind the island chain in a setting much like the present Sea of Japan. Finally, as subduction continued, Africa approached North America and collided with it. The rocks of the island arc were crumpled and metamorphosed and these are what we now see as the metamorphosed sedimentary and volcanic rocks of the Piedmont.

About 180 million years ago the direction of motion changed again. The fissure between the two continents began to open once more. As this happened, lavas which were very similar to the old Catoctin lavas were erupted. As the continents were pulled apart, a series of basins formed that collected debris and alluvial materials that now form the sedimentary rocks in the Triassic basins. As the new Atlantic continued to open, flat-lying sedimentary layers were deposited on the submerged trailing edge of the continent. These rocks are the strata we now see in the Atlantic Coastal Plain. As you see, we have now evolved from a series of isolated observations of where rocks are and how they relate to one another to a picture that begins to make sense on a global scale, both in space and in time. Nobody can say that all details of this interpretation are right, but it gives us an integrating model which can guide our observations and against which we can check some of our conclusions.

So the three main advances in our knowledge of the geology of Shenandoah are: greater knowledge of the regional geology, better understanding of geologic time, and a better integrating model with which to compare our observations.

In closing, it might be worth suggesting some of the lines of geologic research that would be valuable in the future. First of all, I think more detailed studies of the origin and age of the granitic basement rocks is needed. This would give us a clue to the processes and the time of formation of the original continental plate. Also needed is further investigation of the Catoctin lavas: determining their age more exactly, locating the centers from which they were erupted, and learning more about the conditions under which eruptions occurred. Further studies of the sandstones and shales of Chilhowee Group would give us better clues to the direction from which the materials came, the rate at which they deposited,

and the processes that affected them. Another useful group of projects would be studies of details of the deformation and of the metamorphic history of all of the rocks. These studies would give us more insight into exactly what happens during the collision of two continental plates--exactly when the folds and faults formed, and when rocks were metamorphosed.

And last, and I think perhaps to me the most promising and the most exciting research would be studies of the processes by which the landscape is being shaped today--the origin of the talus slopes, the origin of the boulder trains, the relationship between the biologic community and the geologic setting so beautifully illustrated by the discussion of the salamanders in another paper. It should be possible to learn whether those talus slopes are forming today, whether they're moving or stable. All of these are things which should be investigated and I'm sure can be.

Studies of the details of the late Quaternary history of the Appalachians will give us insight into the reasons for the present distribution of the plant and animal species. These studies are at the interface between geology, which goes back billions of years, and archeology and history, that go back thousands or hundreds of years.

MONITORING FOREST INSECT OUTBREAKS

IN THE SHENANDOAH

Timothy C. Tigner*

The gypsy moth is expected eventually to become a serious pest in Virginia. This insect has aroused great public concern in the Northeast, primarily as a severe nuisance in residential and recreation areas. Since prolonged and extensive defoliation has usually occurred on poor sites where trees are of low commercial value, timber production has not been significantly affected.

No one knows what impact the gypsy moth will have in Virginia. In order to evaluate the effects of such hardwood defoliators, the Virginia Division of Forestry has established long-term survey plots in areas of suitable forest type where outbreaks are likely to occur. With cooperation from personnel of the Shenandoah National Park, one series of plots was located across Skyline Drive from below Stony Man summit, near Skyland, to a point above Whiteoak Canyon Falls. Trees in these plots are examined periodically to assess their condition and to monitor changes. Insect populations are evaluated at the same time. By determining forest and insect conditions in this area prior to gypsy moth establishment, we will be able to evaluate the effects of future infestations more accurately.

When survey plots were established in the park during 1974, 12 percent of the study trees were dead or declining in vigor. This reflects the poor site and generally overmature condition of the forest. The same year, an insect called the fall cankerworm caused heavy defoliation of about 300 acres around Skyland. Feeding was less severe in 1975 and is not expected to be noticeable in 1976. Any effects of this defoliation should show up within the next few years. Eventually, the survey plots can be used to evaluate insect sampling

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techniques, population prediction systems, biological control efforts, or selected aspects of environmental impact.

Hardwood defoliating insects seldom cause enough timber loss to justify expensive control efforts; but large areas of defoliation and large numbers of caterpillars do cause considerable public concern for other forest values, and in residential or recreation areas these insects can have serious economic impact. This makes the Shenandoah National Park particularly suitable for long-term evaluation of forest insect conditions. Study plots are likely to remain undisturbed for long periods, and data collection can be modified when necessary to supply information concerning immediate public interests.

QUESTION: Can you tell us a little bit about Dendroctonus?

Well, the southern pine beetle has been in outbreak proportions for a number of years throughout the southeast and is truly an economic pest. It is moving north and can be found not far from here. It's a killer. When it gets into a pine tree the tree almost always dies. It has affected hundreds of acres of valuable forest already. But from my standpoint, if forest insects get into the park, their primary importance is educational. The trees that are here in the park, including hardwoods, are in large part valueless from a commercial standpoint. They are overmature, they are growing on poor sites, and commercial interest in park lands is minimal. There will be pine trees dying; some are dying now in the National Forest south of here. These are largely poorly-formed trees in out-of-the-way places that couldn't be cut if we wanted to. The way market conditions are now, we couldn't sell them if we cut them. My own opinion is that the sensible thing to do with infestations in the park is to study them and try to learn something. We really know very little about most forest insect problems because we have been overwhelmed by their complexity.

QUESTION: How many local species of parasites are there that might be expected to parasitize the gypsy moth?

None that we can be sure about.

QUESTION: Are there any proposals to bring parasites in?

Yes. That has been a big move by a number of agencies including the Virginia Division of Forestry. The problem is that we know so little about the organisms involved. We don't know much about the gypsy moth; we don't know much about the parasites, except which ones they are. A great number have been introduced into this country and a number

have become established. But there is not a satisfactory system yet for sampling the gypsy moth. And the only way to evaluate the effect of a parasite is to see what effect it has on the host, in this case the gypsy moth. To know that a parasite causes 98% parasitism of a given stage is meaningless. It doesn't mean anything at all unless you know what that 98% parasitism does to the host population. Since we cannot yet sample the gypsy moth very well, we don't know the value of any of the parasites.

QUESTION: Are these parasites species specific?

There is a tremendous range. Some of them are monophagous, or host specific. Some of them are terribly polyphagous. One which is established in Virginia - a parasite introduced from Europe - has over 200 known native hosts. We haven't recovered any other introduced species in Virginia. There is no way of evaluating them if we did. Obviously, we cannot establish a parasite unless it attacks insects other than gypsy moths, because we don't have the gypsy moth yet. We have to introduce parasites that can survive on something else. That is not an easy thing to do, and often you never know whether you have done it or not.

[illegible]

