

REPORT ON PATHOLOGICAL CONDITIONSIN MESA VERDE NATIONAL PARK.

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by

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The examination of tree growth in Mesa Verde National Park, on which this report is based, was made June 1-4. Its particular object was the determination of the causes for the generally unhealthy appearance of piñon and the reported dying of young junipers.

General Forest Conditions: The soil on the mesa is rather poor. A shallow layer overlies the solid sandstone which forms the main body of the mesa. The soil is sandy, deficient in humus and has a low water-holding capacity. The entire plateau is extremely poor in water. Annual precipitation is normally small in amount, and very little of it is stored in the ground. There are but few springs located in the deep and narrow canyons cutting through the mesa, and even for human use rain water is collected and stored. The vegetation on the mesa depends for its water needs immediately upon precipitation in form of rain and snow so that any deficiency in precipitation must make itself felt. The older trees are

deeply rooted in the cracks of the underlying rock where they find sufficient moisture to tide them over unfavorable periods. The younger trees, on the other hand, are far more subject to unfavorable moisture conditions since their roots are located in a thin layer of earth, the water content of which fluctuates rapidly with rain or dry weather.

Piñon (Pinus edulis) and juniper (mainly Juniperus utahensis) are the character trees of the mesa forest growth. Associated with them are shrubby species, among which Amelanchier and Fendlera are numerically prominent. Tree growth is short and stunted, in open formation, with scanty reproduction.

All wild plants of a given site and association have established themselves, and grow, under a set of conditions which influence their life and development. These conditions may be beneficial or injurious and form, in their totality, what may be called the "normal complex". This complex is the one to which the vegetation is best adjusted, and the adjustment results, in the present case, in the type of forest trees clothing the Mesa Verde plateau. The result of the reactions of the trees to climate, soil and injurious factors has shaped the stands as they are today. They make up the normal complex. When one or more injurious factors become intensified or when a normally beneficial factor weakens or temporarily disappears, the fine balance of adjustment is disturbed, the health of the

trees is impaired, and a pathological condition results which expresses itself in the unhealthy appearance of the trees or their death.

General Pathological Observations: Piñon in the park is more or less heavily attacked by two needle diseases, both caused by species of *Hypodermella* (tentative determination), one of which causes the formation of witches' brooms. I understand that what is probably a rust fungus attacks the needles severely later in the year. The insect situation, according to the findings of the Bureau of Entomology, is not serious. Porcupines have caused alarming damage, particularly along the main road on the North rim of the mesa where fine groups of unusually large piñons stand out from the wide sweep of brush land in striking beauty. These groups are today badly injured by porcupines. If the damage is permitted to continue these piñons, instead of being a great scenic asset, will turn into an ugly blot on the landscape.

The Utah juniper in the park is normally beset by a number of troubles. Besides mistletoe, which is common, there are four different species of rust fungi (*Gymnosporangium*) present, each one common and undoubtedly injurious. In fact, I have rarely seen so heavy an infection with rusts on junipers. *Gymnosporangium* belongs to the group of rust fungi that alternate between conifers and other plants, in this case,

Serviceberry and Fendlera. There seem to be also two species of Hypoderma-like fungi present. I have further observed an extraordinary infestation of mites, especially on the smaller seedlings, but I have no means to evaluate the damage they are undoubtedly doing.

All these diseases of piñon as well as of Juniper appear to be more or less evenly distributed within the stand, but there is a marked difference in the condition of trees standing on the edge of the canyons and around clearings and burns, in fact everywhere where they are exposed to the free play of the winds. These trees are practically free from the parasitic diseases which are so prevalent in the interior of the stands. One cannot but assume that the stagnating air within the stands prevailing during certain periods in the life history of the parasitic fungi creates particularly favorable conditions for infection of the trees.

Special Findings:

Piñons: None of the injurious factors mentioned above appear to be present in such numbers or in such intensity that they individually or collectively could be made responsible for the undoubtedly heavy browning of the needles, which is mostly confined to the older needles. It is rather my impression that, in addition to the various needles diseases, certain unfavorable conditions, in particular water deficiency, are

largely responsible. The root system, which is no longer provided with the full amount of water needed, is reduced and the tree endeavors to restore the balance between roots and foliage by eliminating the least useful older needles. It is a form of what I call retrenchment, an adjustment to a changed condition. If my view is correct, the piñons should recover when the pendulum swings back to more normal water relationships. It is, of course, possible that the rust fungus which is said to appear later in a very heavy infection may be of greater importance than can now be ascertained. Such a fungus (probably a *Coleosporium*) is, however, part of the normal complex. It is surely not introduced from the outside. While fungi of this type do fluctuate in intensity under the influence of varying weather conditions it is improbable that they should appear in the form of an overwhelming epidemic. Since the needle-inhabiting fungi, such as *Hypodermella* and the rust fungi, fruit and show up more prominently later in the season it seems advisable to make another examination in the fall.

From the scantiness of reproduction of piñon it may be inferred that young seedlings often have difficulty in establishing themselves. It appears that frost heaving, which is very pronounced, is one of the important inhibitive factors. Undoubtedly also a great number of young plants die in earliest

youth from a lack of water, before the young roots can reach down into, and establish themselves in, the soil.

Junipers: Juniper reproduction is, on the whole, a little richer than that of piñon. There is no doubt that very many seedlings from 6 inches to 3 or 4 feet in height give the appearance of being dead. The juniper seedlings stand out sear and yellow and leave an unpleasant impression of ugliness along the roads and trails. Closer examination shows that the great majority is not really dead. The upper part of the main stem and the yellow branches and twigs are undoubtedly dead and dry, but not only is the larger part of the stem still alive, but at the base there are generally young shoots coming out, proving definitely that there is life in the plants. The lower young shoots and unfolding buds are vigorous. They become weaker the higher up they are located on the stem.

This also I look upon as a form of retrenchment, only taking on a form different from that in the piñons. Juniper discards from its functioning body as much of the top as is necessary to restore its balance with the root system impaired by water deficiency. Retrenchment is not confined to seedlings. The older junipers in Mesa Verde generally have several stems, one or more of which may be entirely eliminated. These dead stems are not killed by any direct attack of fungi or insects, and it is highly improbable that the parasitic fungi described above should have been the cause

of the death of just these stems and not of others equally heavily infected. It seems far more probable that this dying of individual stems is but another form of retrenchment.

Climatological History: If water deficiency lies at the base of the undoubtedly abnormal browning of piñon needles and of the die-back of young junipers the proof should be found in the water history of Mesa Verde. Unfortunately, the precipitation records of Mesa Verde have been kept, uninterruptedly, for only seven years. This period is too short for the establishment of fairly reliable averages. A comparison with the weather records of Durango, a station at no great distance from Mesa Verde, shows differences in actual amounts of precipitation but at the same time a parallelism in general trends which strengthens the average computed from the Mesa Verde data.

The average annual precipitation seems to lie somewhere near 18 inches, an amount which is perilously close to the lower limit of water supply for tree growth on soils of low water retention. Meager snowfall in winter provides but a scanty storage. Much of the annual precipitation is made up of torrential rains in summer, with consequent heavy run-off and high evaporation due to the excessive heat. The following table shows the total annual precipitation for the seven years for which consecutive records exist:

1924	-	18.37"
1925	-	19.23"
1926	-	20.97"
1927	-	22.68"
1928	-	14.07"
1929	-	17.83"
1930	-	14.26"
Average		18.18"

Of the 18.37" of 1924 more than half, 10.56", fell in three months. The relatively high figure of 20.97" for 1926 is explained by the excessive rains of April with 7.31". Five months had less than an inch and of the remaining months only one, July, rose above 2" rainfall. For all practical purposes this year must be classified as dry in spite of the high total of 20.97". In 1927 more than one-half of the year's precipitation fell in three months, the rest of the months being very dry. In 1928 the highest precipitation in any one month was 2.80", the lowest 0.03", and in six months the amount was less than one inch. In 1929 more than one-half of the total precipitation for the year fell in three summer months, all the rest of the year being extremely dry, so that this year, although its total was almost up to normal, was in reality a relatively dry one.

It is obvious that the totals of precipitation for any one year cannot be used as a gauge of water supply for

vegetation. A closer analysis is needed. For this purpose a water budget was drawn up, in the form of a profit and loss account on a monthly basis (see the attached chart.) The chart covers the years 1928, 1929, 1930 and the first four months of 1931. Since any adverse or beneficial effects of years previous to this period are now most likely masked, as far as the purposes of the present examination are concerned, it seemed more profitable to confine the analysis to these more recent three and a quarter years.

The heavy black line gives the average monthly precipitation in inches. The black broken line represents the actual monthly precipitation. The comparison of the two lines brings out strongly the summer drought of 1928, the early summer drought of 1929, the torrential rains of midsummer 1929, the fall and early winter drought of the same year, the spring drought of 1930, the heavy rains of July and the fall and winter drought of the same year.

Even this analysis does not tell the whole story. When the monthly excesses and deficiencies, in relation to the average monthly amounts, are plotted cumulatively a truer relationship becomes apparent. The cumulative excesses and deficiencies are shown in the solid red lines, individually for 1928, for 1929 and for the period 1930 to April 1931, and illustrate far more strikingly how the plant world fared in

its water budget during these individual years. This profit and loss account is finally carried on from 1928, in the broken red line, through to April 1931, showing a final deficit of 8 inches for 3 1/4 years.

This red line needs further interpretation. What we are interested in is the probable after-effect of rainfall on vegetation. The loss from run-off in torrential rains is very heavy. Consequently the large amounts that fell in July, August and September 1929 and in July 1930 must be correspondingly discounted. Furthermore, even the residue of these heavy rains, after deduction for run-off, is not fully available for plant life on account of the excessive evaporation taking place during the very hot and dry summers of Mesa Verde.

In accordance with these considerations an attempt was made to interpret the red line of cumulative excesses and deficiencies with regard to the probable after-effect on plant life (green line). Heavy summer rains are more or less arbitrarily, but conservatively, discounted, slow and penetrating rains in the cool and cold months are given higher values. The result is a loss of nearly 10 inches in 3 1/4 years. In a region where the average annual precipitation is closer to 16" than to 18", if the torrential rains are discounted, this loss is surely a heavy one. The deficiency has gone through 3 1/4 years and is cumulative in its physiological effects.

It is obvious that run-off and summer evaporation are not the only modifying factors in the establishment of a true water budget. Evaporation goes on through a large part of the year, and a considerable portion of the water is utilized by the ground cover. Wind velocities, atmospheric humidity and temperature are important factors in the equation. The actual relationships could be worked out only on the basis of long-term and intricate observations without promising, in the long run, more illuminating results than the analysis illustrated above. In Mesa Verde the case is particularly simplified by the fact that there is practically no water storage in the shallow and highly permeable soil.

To judge from the type of injury and general appearance of the trees and from the weather history I feel confident that in the end the main trouble as it appeared at the time of the examination can be traced to the unfavorable climatic conditions of recent years, low precipitation and poor seasonable distribution and that the resumption of normal weather conditions will bring recuperation of tree growth, provided that the plants do not again suffer too severely from excessively dry periods and provided that the summer months bring adequate moisture. It is obvious that many weaker individuals have already dropped out definitely and that a very great number of trees now stand on the verge of

death if the downward trend of the already submarginal water supply continues.

Recommendations: No actual control work is necessary or advisable. The dead tops of the junipers should be pruned off with pruning shears along roads and trails for the double purpose of eliminating an ugly feature and to give the plants a chance for recovery. The guiding principle should be to cut down to the vigorous young shoots. The weaker buds and shoots which appear a little higher up on the stem only take water and food from the stronger ones. The method will give the individual plant a chance to concentrate on the more vigorous buds and shoots. This work should be done with discrimination and care. It is not necessary to burn the offal.

This procedure is, however, not recommended for the larger trees in which whole stems and limbs have died. What is ugly in a considerable number of small plants becomes picturesque in large specimens. The elimination of such limbs or stems is recommended only wherever they may occur in too great a number near roads and trails.

In the piñons no control work is necessary except here and there for insects, where necessary, and for esthetic reasons. The trees should revive with the resumption of more favorable moisture conditions.

MESA VERDE WATER BUDGET

Monthly Precipitation - Profit and Loss
1928



