THE EFFECTS OF A VOLCANIC CINDER FALL ON TREE GROWTH

BY J. C. McGREGOR

For some time the Museum of Northern Arizona has been interested in the effects of the eruption of Sunset Crater on the life of the prehistoric Indians who were inhabiting the region at the time of the volcanic activity. Colton ,(1932), has shown that the distribution of late Pueblo II sites and early Pueblo III sites corresponds to the distribution of the volcanic ash. (1) He also showed that the lower limit of Pinus ponderosa, and Juniperus monosperma, drop approximately 1000 feet in altitude in the ash fall region. This suggests that the volcanic ash is an important ecological factor in the distribution of present day forest, and gave rise to the thought that measurements of tree rings from trees growing in the ash covered area when compared with threes growing nearby in soil not covered by ash might throw important light on this unusual distribution of the pines.

Although both A. E. Douglass, (1928), (2), and G. A. Pearson, (1931), (5), had previously noted certain effects of cindery or volcanic soil on the growth of trees, particularly the Western Yellow Pine, and F. W. Haasis, (1921), (3), has noted the effects of cindery soil on the growth of Western Yellow Pine seedlings, no specific work had been done on this problem at the beginning of our investigation. It is because of this fact that the results herein contained are felt to be of some interest.

Sunset Crater, where the most recent of all volcanic activity connected with the great San Francisco volcanic field, Arizona, has occurred, (Colton, 1932; and McGregor, 1936), (4), is the center of the area studied. The general ground surface consists of old and greatly weathered lava terraces upon which were dropped quantities of coarse cinders, (lapilli and scoria), from the eruptions of the neighboring ancient cinder cones. Following deposition these cinders have been oxidized red, and where moisture penetrated them they have broken down and weathered to form a compact yellow clay, which covers the cinders and penetrates them to a depth of several feet. While this clay was being produced, land surfaces were eroded and sculptured to about their present forms, to produce the conditions preceding the Sunset eruption.

With the eruption of Sunset Crater, almost unbelievable quantities of black basaltic sand, (ash), and lapilli were poured out upon this land surface, spreading about the cone in an ellipse whose major north-south axis was about thirty-six miles, and whose minor axis was about twenty-eight miles, (Colton, 1932). Immediately about the cone, cinders, (ash, lapilli and scoria), piled up to some depth. Toward the periphery of the ellipse only the finer products fell, ash in the form of black sand, for the fine particles of ash were readily transported by the strong prevailing southwesterly winds.

Many of the hilltops were soon denuded of ash, and a few of the tablelands swept bare. But the removal of this material in certain sections caused the formation of dunes in others where some obstacle favored their building. Often a canyon or valley acted as such a trap.

To compare the rings of trees in ash covered areas with those of nearby regions free of ash, small cores were removed from the trees with a Swedish Increment Borer. A total of 184 borings were made by this means. In the collection of these specimens an attempt was made to keep several factors in mind. First; the thickness of the cover of cin-

ders above the clay surface was always noted. Second; the slope and exposure of hilltops, hillsides and flats were carefully noted and an attempt was made to collect specimens from each type of site in equal numbers. Third; an attempt was made to collect about an equal number of young trees, mature trees, and very old trees, thus to equalize the varying effects of age on ring size.

When representative material, growing under varying conditions had been colected, it was decided to measure the last ten rings of every sample. This would include the period of growth from 1922 to 1932, (the latter date that of collection), which would assure corresponding rings and period of growth in every case. Thus the rainfall factor would be controlled, for in a small area we may assume that the rainfall in a given year would be the same in all parts. Ten rings were chosen because that number facilitated computation, and because laboratory equipment for individual ring measurement was inadequate at the time. All of the trees which were collected from one specific section, and which were grown under similar conditions, were then averaged and reduced to the basis of one ring as measured in millimeters. The accompanying table presents the results of this computation.

TABLE OF RING SIZES

Location	Ash depth	Subsoil type	No. of specimens	Aver. ring width mm.
Tuba highway near Sunset Crater	No ash cover	Yellow clay from old cinders	12	.60
Lower Medicine Valley	No ash cover	Sand, Gravel	18	1.00
South side of Crater 45, gentle slope	4″ to 6″ deep	Old cinders weathered to clay	12	1.56
East side of Crater 45, gentle slope	6″ to 10″ deep	″	12	1.65
Flat area west of Sunset Crater	10″ to 15″ deep	″	31	2.14
″	6″ to 10″ deep	″	23	2.26
Black windblown cinders banked against Bonito flow	6′ to 10′ deep	Alluvial material	7	2.36
	Over 10′ deep	″	8	2.40

Obviously, in all of this work the factor of human error plays a very important part. An example of such a condition is apparent in the bottom line of the table. Here great banks of windblown sand had been piled against the end and side of a tongue of the Bonito Lava flow. The difficulty of determining actual sub-cinder conditions arises from the fact that this flow moved up a valley and dammed what once was an avenue of drainage from the higher backland. Therefore, water is probably now stored against the end of this flow, and would account for the unusual large size of rings of the trees growing at this place. Again, the trees growing in the crevices of the Bonito Flow show extreme ranges of ring sizes. (This data not included in the table). This would indicate that certain cracks in the flow form veritable cups for the retention of all the moisture that falls. As this section of Arizona has a relatively dry climate, (about 15 to 20 inches annual rainfall), any means of conserving moisture is of paramount importance.

A comparison of trees grown in old cinders weathered to clay, with and without an ash cover, is the most convincing of all the material col-

'ted and studied. Here most careful observations of cinder cover, ainage, etc., were made.

It would appear fairly obvious that a cover of cinders over a clay or alluvial base greatly increases the size and growth of rings of the Western Yellow Pine. In view of the nearly equal precipitation over the area studied, and the obvious lack of plant food in the unweathered cinders from Sunset Crater, we conclude that the ash acts as a mulch to conserve the scanty water supply.

A glance at the table will bear out these conclusions. It will be seen here that the most ideal conditions for tree growth were represented in areas where about six to ten inches of rather fine cinders, or ash, covered a clay surface, and the drainage slopes were gentle with no prominent valleys.

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DATES FROM FIVE KIVA HOUSE, UTAH

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The material which this communication concerns, consisting of two beam cross-sections, was deposited with the Laboratory of Anthropology in the summer of 1936, by Mr. Deric Nusbaum, at that time with the National Park Service, and Mr. Zeke Johnson, Custodian of Natural Bridges National Monument. Mr. Nusbaum and Mr. Johnson provide the following information regarding the provenience of the specimens.

Five Kiva House is located in a cave on the west side of Westwater Canyon three miles southwest of Blanding, Utah. Associated with the five circular, subterranean kivas from which the ruin takes its name are some twenty-odd ground floor rooms. Mortar marks on the roof of the cave near its two ends suggest that rooms formerly rose to two stories in these places. Although smaller sites are numerous, Five Kiva House is the only site as large as this in the vicinity and is, accordingly, easily identified. The cave has been used as a picnic ground by the local inhabitants with the result that the ruin has been considerably mutilated. Walls are still standing, however, and structural timbers yet can be found in place. Both of the timbers concerned here were fragments, found in fallen debris.

The specimens are pinyon, in sound condition; both have excellent records, although one is quite short; and both were cut between the growing seasons of 1243 and 1244.

A small collection of sherds from the site, kindly supplied by Mr. Johnson, contained Pueblo I and Pueblo III material, dividing about equal-