the deformation of tombstones under their own weight in a cemetery in Washington, D.C., and quotes several instances of rock flow from ancient structures in the old World. In an old cemetery in Richmond, Virginia, the writer has noticed a pronounced concavity of tombstones which consisted of horizontal slabs mounted on brick pillars at the four corners. Slow flow and 'elastic after effect' has been determined on bars of rock cut from the coal measures of England. Bingham and Reiner have shown that long slender bars (about 1 inch square by 33 inches long) of thoroughly cured cement mortar bend appreciably under their own weight in a few months. Flow of marble slabs, probably from forces arising from diurnal temperature changes, has been noticed in a cemetery in Havana, Cuba. All the evidence quoted on the flow of rocks shows only small deformations, but they were caused by small forces (in most cases, of the order of the weight of the rock) and for times which are infinitesimal in comparison with geological time.[21]

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ARE THE BRISTLE-CONE PINE TREES REALLY SO OLD?

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Various treatments were given to 8-month-old bristle-cone pine seedlings; and it was found that supplementing the winter day length with a 250-watt heat lamp in order to give a total of 16 hours of illumination proved most effective. The lamp was placed about three feet above the seedlings, and the temperature in the growth chamber was kept at about 70°F. Those which received a short (circa 21 days) drought stress period in August of the third growing season showed up having one more growth ring than the control seedlings, that is four growth rings instead of three.

Also seedlings which received a two week drought stress period in August of the fourth growing season showed a similar extra growth ring.

The bearing of this on the estimates of the age of the bristle-cone pine forest is discussed. Under the San Francisco type of both spring and fall rainfall with a relatively dry period in the summer the young forests on the White Mountains would have grown an extra ring per year quite often. Accordingly it is believed that the presumed 7100 year age postulated for these trees by Ferguson would be reduced to about 5600 years, on the assumption that extra rings would be formed by stress during about 50% of the years between the end of the Flood and about 1200 A.D.

Introduction

In his paper, "Bristlecone Pine: Science and Esthetics," C. W. Ferguson points out that in some species of conifers one season's growth increment may be composed of two or more flushes of growth, each of which may strongly resemble an annual ring. Such multiple growth rings are extremely rare in the bristlecone pine, especially in the White Mountain area, according to Ferguson.[1] Now this range of mountains is located east of the Sierra Nevada and separated from

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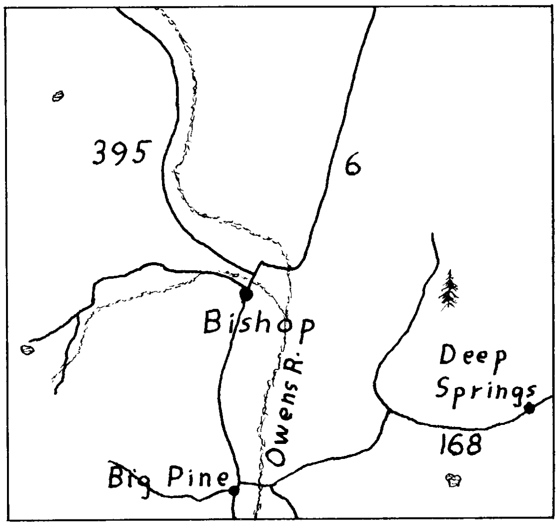

Figure 1. The region in which the bristle-cone pines grow, in the vicinity of Bishop, California. Nevada is to the right. The tree sign shows a place, in a park, where the trees may be seen. Highway numbers are shown on some of the roads.

it by a fairly wide desert valley. It is about 14 miles east of Big Pine, California which is 15 miles south of Bishop, and may easily be reached by going out highway 168 from Big Pine. A paved highway goes north to the entrance of this Ancient Bristlecone pine area as shown on the map in Figure 1. When we visited this park on August 23, 1973, we saw two species of pine. One was a fairly long greyish needled one called *Pinus flexilis,* and the other a shorter needled one called *P. aristata* or bristlecone pine so named because the scales of the cone have slender bristles on the ends of them.

The great age of many of the trees in this park is most impressive, though it may be a surprise to most readers that the oldest living trees are presumed to be about 4600 years old. The age of 7100 years is reached only by the addition of rings from long-dead specimens to the record of the living trees. The pattern of the ring formation in these older trees is distinctive enough from that of the younger ones that there seems to be no question as to their having been formed earlier.

My own observation of the growth of this pine confirms the claim of Ferguson that they are singularly difficult to influence as regards their growth and formation of annual rings. However, as will be shown, it is possible to do so under circumstances which may well have occurred many times in the habitat in which they are growing.

Material and Methods

The growth studies of this pine were done in a growth chamber constructed in my greenhouse. The supporting 4x4's are 12 feet apart. So I nailed 2x4's to the side of the central bench extending them to the plastic supporting beams of the greenhouse, placing them at the same distance apart as the 4x4's, or 12 feet. Now the 4x4's are 4′8″ from the outer edge of bench and 7′8″ high above it. The 2x4's are 6′8″ high. By placing 4 mil polyethylene around these both on the outer and inner side it was possible to make a fairly good heat retaining chamber 4′8″ by 12′ and sloping from 6′8″ to 7′8″ high. A 250 watt heat lamp was used as well as fluorescent light tubes. Also a small electric heater which was equipped with an automatic control was used to keep the temperature at 70 degrees F.

Seed of the Colorado strain of the bristlecone pine was purchased from the Clyde Robin Seed Co., Inc., and planted March 9, 1978. By way of explanation, because of park restrictions it is practically impossible to get seed of the trees growing in the White Mountain area. However, botanically speaking, the trees growing in California and in Colorado are all considered to be the same species. Germination was excellent and the seedlings were transplanted on April 6, 1978 to small plastic pots using a commercial planting mix. They were given a balanced high nitrogen 25-10-10 nutrient solution at the rate of two teaspoonfuls per gallon on August 16, 1978, and January 16, March 9, and March 24, 1979.

On December 23-24, 1978 the seedlings were divided into 5 groups. Twenty-two were placed outdoors after being transplanted into four-inch pots. These were buried in the soil so that the top of the pot was level with it. In this way maintenance was reduced to a minimum and growth conditions were made as similar to natural conditions as possible. This group is designated as "outdoor" in Table 1. A second group of 25 plants were transplanted to five-inch pots and placed in the greenhouse where the temperature dropped to as low as 40 degrees F at night during January and February. This second group is designated as "Greenhouse" in Table 1. Group three consisted of 22 seedlings which were transplanted into four-inch pots and placed in two rows of 11 plants each so as to receive as much sunlight as possible. These are the "70 degree minimum no extra light" plants of Table 1. Twenty seedlings were transplanted into five-inch pots and placed in a circular arrangement so as to receive as much light as possible from the 250 watt reflector red heat lamp placed three feet above them. They are called "Heat lamp, 16 hour day 70 degrees minimum" in Table 1. Finally the remaining 12 were transplanted into five-inch pots and placed directly under the fluorescent light tubes about four feet from those under the heat lamp. They are the "Fluorescent light, 16 hour day" group of Table 1. The fluorescent lights were six feet above these plants and so actually illuminated both the plants under the heat lamp and these 12 plants. Both 4- and 5-inch pots were used since at the time there were not enough empty pots of either type available for the whole experiment. Since the seedlings were still so small actually 4-inch pots would have been adequate.

The plants out of doors were placed under a mist type nozzle on the end of a hose held about 2½ feet above the ground by strapping the hose to a 1″ by 1″ stake. The mist was set to go on each day at noon and so the plants were kept at nearly 100% humidity during the summer and fall until September 20, 1979. They and all the other seedlings which received the treatments described above and removed to this location in May of 1979 were given the same type of mist treatment in the summer and fall of 1980 and 1981.

Table 1. Increase of growth in height of *Pinus aristata* seedlings during a period of about 3.5 months. (December 24, 1978-April 6, 1979)

Treatment during the 3.5 month period	Total number plants in treatment	Number of plants showing various height increments (in inches)										Summated total; of increments for all plants in treatment	Average height increase for each plant
		0	0.125	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00		
Outdoor	22	10		9	1	2						4.25	0.19
Greenhouse	25			6	4	3	5	3	2		2	21.5	0.86
70 degrees minimum with no extra light	22	9	2			1	7	2			1	12.5	0.57
Heat lamp 16 hour day, 70 degrees minimum	20			1		3	2	1	6	2	5	28.25	1.41
Fluorescent light 16 hours per day, 70 degrees minimum	12	2				1	4		4		1	12.25	1.06

Results

The results of these experiments may best be summarized by describing them in three parts, namely, the effect of various light treatments, then the age of the bristlecone seedlings when the first annual growth ring is formed, and finally the effect of various treatments designed to induce extra ring formation.

1. Effect of light treatments on seedling growth

Since the plants were a year old on April 6, 1979, measurements were made of their increase in height between December 24, 1978 and April 6, 1979. When these seedlings were transplanted they all were 1 to 1½ inches high. Ten height increments were established at 1/8 inch (0.125) intervals from zero on up to two inches. Each plant was placed in the increment class to which its height increase most closely corresponded. Plants showing little or no growth were placed in the zero class. At this time the seedlings were so small that slight diameter differences could not be measured. These data are given in Table 1.

The seedlings outdoors did not resume growth until the end of March 1979; so the small amount of growth recorded occurred in about one week of time. With warm days beginning in May they all began growing and continued to make slow growth until mid-August. Though measurements of their growth were not made, the average was less than half an inch per plant.

Those kept in the unheated greenhouse did not begin growth until about March 15, 1979. The total growth of 21.50 inches all occurred in about three weeks and averaged 0.86 of an inch per plant.

The plants under normal day length and temperatures of about 70 degrees F minimum with maximum exposure to the sun made a total growth of only 12.50 inches or an average of 0.57. Quite evidently, higher temperature alone is not enough to cause extra growth. In fact it seems to have a detrimental effect, since it deprives the seedling of normal winter chilling without giving it any extra light stimulation.

The much greater stimulation of the seedlings under the heat lamp was quite remarkable, especially since the experiment had run for only slightly over three months. (Figure 2) The average amount per plant of 1.41 inches is considerably more than the average of 1.06 made by the plants under fluorescent light. Since I needed the chamber space to force seedlings from the seed of ornamental plants collected in Chile in 1978, all of the plants were moved outdoors in May of 1979.

These various light treatments indicate that although the bristlecone pine is not as easily influenced by the length of day as other pine species, it can be stimulated significantly, especially by long-day heat-lamp treatment. The bearing of this on the rapidity of their growth under conditions formerly existing in the Owens River Valley and White Mountain area will be discussed later.

2. Age of seedling at first annual ring formation.

My first attempts to influence annual ring formation were made by subjecting seedlings to cold storage treatment at 40 degrees F for three weeks in May of 1979. No outward effect was noticeable and examination of cross sections showed no interruption of growth. A similar attempt in 1980 was also unsuccessful.

Examination of the cross sections of several seedlings when one year of age (April 6, 1979) showed only pith growth. Evidently it takes a young bristlecone pine seedling a long time to grow out of its juvenile state. Even in late September of 1979 they showed only a small amount of woody tissue consisting of 9 to 12 circles of cells. No distinction between spring and fall growth could be seen. In order to recheck on this behavior I planted another packet of seeds on June 7, 1980. These germinated in about a month and were

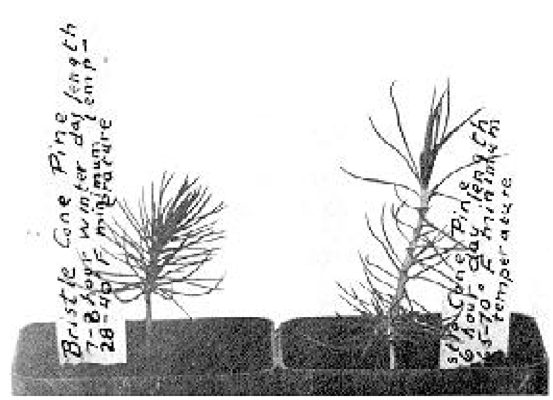

Figure 2. Showing added growth from exposure to the heat lamp, December 24, 1978, to April 6, 1979, by the seedling on the right. The seedlings are shown actual size.

transplanted to small plastic pots a few weeks later. They made very little growth in the summer and fall. Cross sections showed only pith growth. Since the greenhouse was unheated they made no growth in the winter. Late in the spring of 1981 they began growing and were about 1 inch high by December 1981.

I then made cross sections of several of these seedlings which by then were 1½ years old and a photograph of one of these sections is shown in Figure 3. Though not nearly as clear as when examined under the low power lens, this photograph does show that a considerable amount of wood tissue had been formed. Actually there are nine circles of cells in addition to the pith in the center.

These seedlings were left growing in the greenhouse all during 1982 and by December were 1½ to 2 inches tall and had increased considerably in diameter. A cross section of one of these seedlings clearly showed the central pith cells, the nine to twelve circles of wood tissue cells, and a spring and fall growth, or only one growth increment in addition to the central area formed in its first 1½ years of growth.

It is clear then that a bristle cone pine seedling which shows one growth ring is actually 2½ years old: a rather unexpected conclusion and certainly one which I never anticipated when this study was begun.

3. Effect of various treatments

As mentioned above attempts to induce extra ring formation by cold storage treatments were unsuccessful. Meanwhile I had read Philip R. Larsen's article

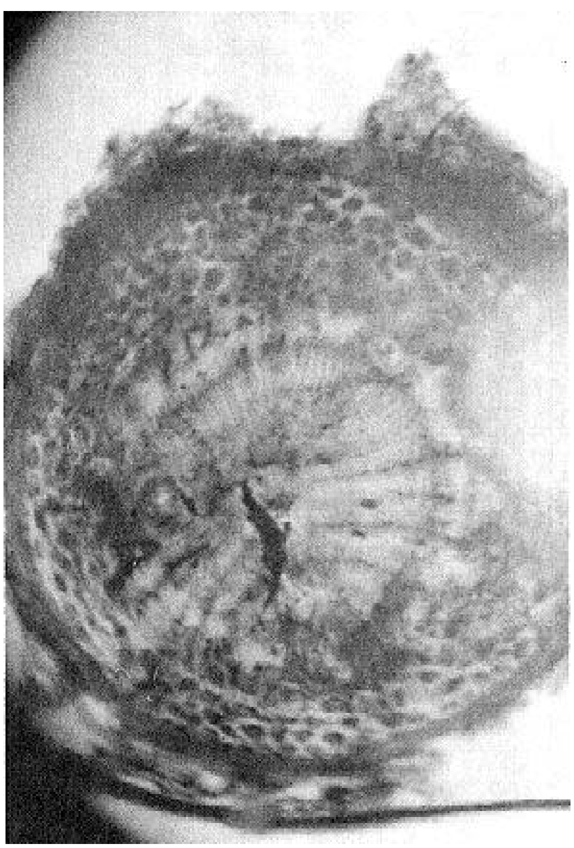

Figure 3. Cross section of a 1½ year old seedling x 64.

entitled "Auxin gradients and the regulation of cambial activity" in the book *Tree Growth.* He stated that drought occurring during the period of active elongation can result in the temporary suspension of growth and extra ring formation in the larch and other deciduous trees.[2] Accordingly I decided to try this treatment on my bristlecone pine seedlings all of which had been moved outdoors and placed under the mist system in May of 1979. So on August 5, 1980 I removed six seedlings of the original outdoor group (those which had been transplanted on April 6, 1978), placed them on a bench in the greenhouse, and did not give them any water until August 26, 1980. It is amazing how long the bristlecone pine can live without the pots being watered! For at the end of this three week period, though of course all growth had been checked, the plants did not seem to be suffering very much. The humidity of the greenhouse reduced the stress; but even so any other plant which I know of would have been dead in less than a week without water, except of course cactus.

When these seedlings were removed to the ground area under the mist system they resumed growth in about one week and continued growing until late September, an unusually hot month, and did not form the usual terminal buds until in October.

Then on August 3, 1981 I removed six seedlings to the greenhouse bench and kept them there until August 18th without watering them. They were then replaced in the ground under the mist system where they soon resumed growth and finally formed terminal buds in October.

Examination of cross sections

In December of 1981 I made cross sections of the seedlings which had been given drought treatments and examined them under the low power objective to see how many growth rings had been formed.

The central area of Figure 4, a cross section of an untreated seedling, may be recognized as the growth of the first year and three quarters. The pith and central area has grown to the tripartite figure in the center which extends to the end of the first year's growth. Then the light colored area is the spring growth of the second year, and this ends at the two small resin ducts indicated in the figure. The darker fall growth ends at the somewhat larger duct about 5 inch above the two. Then the spring growth of the third year begins and ends at the large duct about ¼ inch above. All of the rest is the late summer growth clear to the margin where the bark tissue begins.

Figure 5 shows a cross section of a three year old seedling which was kept in the greenhouse without water for 15 days. Only a small portion of the central area is shown. The three growth rings in addition to the first year and three quarters of growth are fairly clearly shown. Accordingly this seedling gives the appearance of a four year old plant in contrast to the untreated one which showed only two growth rings.

Figure 6 shows a cross section of a seedling which had been dried out for three weeks in August of 1980. Here also a total of four growth rings are quite clearly shown. Actually these were very much clearer when actually observed under the low power objective, but

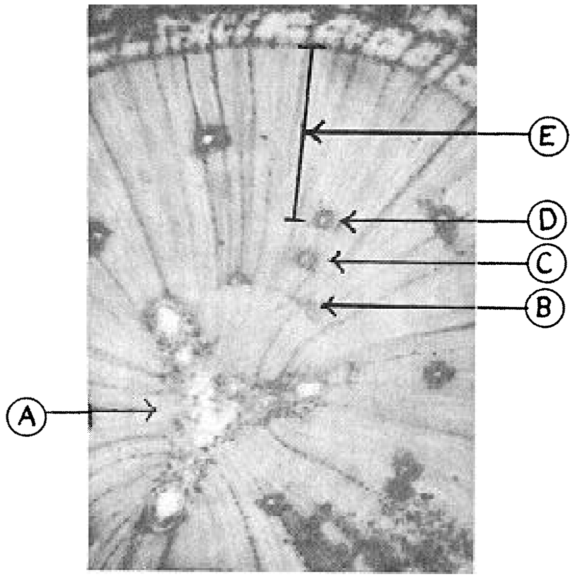

Figure 4. Cross section of a three year old seedling. The central area is the first year growth. It is bounded by the tripartite pith area. The spring part of the second year's growth ends at the two ducts; fall growth at large one. The third year spring growth ends at the duct just above it and all the rest is late summer growth. Key: A: tripartite pith mass in center; B: end of second year's spring growth; C: end of fall growth; D: end of third year spring growth; E: third year fall growth.

it was very difficult to get equally clear photographs of these cross sections.

A further contributing factor which helped the seedlings survive for three weeks without water was the foggy weather during most of August 1980. During most of the time the fog lasted until noon or even

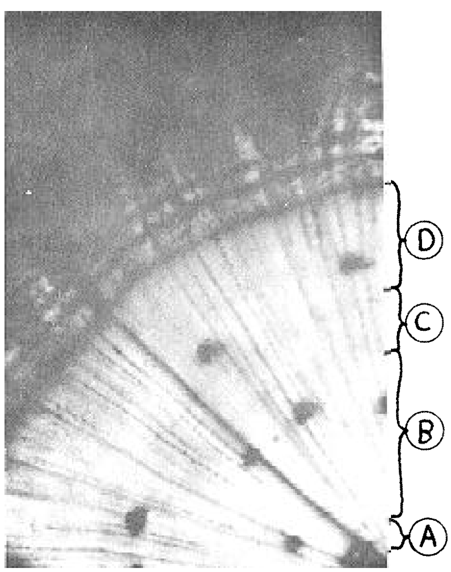

Figure 5. Cross section of a seedling which was kept in the greenhouse without water for 15 days. The dark area at the bottom right is the outer part of the first year's growth, unfortunately shown in this photomicrograph, the only one taken after the two week treatment. The three growth rings in addition to the central one are quite clear, and are indicated. Key: A: outer part of first year's growth; B: second year growth ring; C: third or extra ring; D: fourth ring.

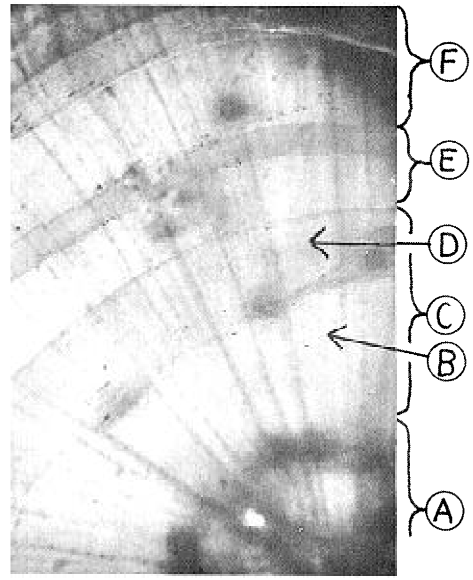

Figure 6. Cross section of a three year old seedling that was dried out for three weeks when it was two years old, from August 5 until August 26, 1980. The sharp differentiation at the edge of each ring is caused by heavy absorption of iron aceto carmine stain at the boundaries of each growth period. x 40. Key: A: first year; B: spring growth; C: second year; D: fall growth; E: extra ring caused by drought for three weeks; F third year.

later. The few sunny days were very cool and the humidity was very high. September is always one of our hottest months and this, no doubt, was a strong factor in the ability of the seedlings to resume growth after being dried out for the two and three week periods. They were of course fertilized soon after being replaced in the ground under the mist system.

Seedling size is given in Table 2. Here we may note that the largest diameter plant among the control or untreated plants is 0.1875 inches which is just barely as wide as the smallest among those dried out for three weeks. Two plants among those dried out for two weeks in August 1981 were 6½ inches high as compared to 4 inches for the tallest of the untreated plants.

In January of 1982 the remaining untreated seedlings were planted in three locations, that is 8 of them under the mist system, 8 in a basin area near several rows of *Leptospermum* hybrid plants so they all could be watered by one sprinkler setting, and the remainder in a row near my greenhouse. All three groups of

Table 2. Range in size of seedlings in December, 1981

Type of Treatment	Number of seedlings (originally all about 1-1.5 inches high)	Lowest widest diameter in inches	Shortest and tallest plants in inches
Dried out 3 weeks; August 5-August 26, 1980	6	0.1875-0.25	3-4.5
Dried out 2 weeks; August 3-August 18, 1981	6	0.1875 (all seedlings)	3-6.5
Control—other seedlings not dried out	6 (average ones of total)	0.125-0.1875	2-4

plants were kept wet during the 1982 growing season, by furrow irrigating the ones in the row, sprinkling the ones near the *Leptospermum*, and using the mist system on the others. I quit watering the two groups of 8 plants August 31, 1982 since growth appeared to have stopped by then. The ground was very dry by September 15th. It rained hard September 23rd, so I resumed watering all the seedlings once per week. Growth did not entirely cease, after starting again following the rain, until about the middle of November.

Cross sections of two plants of each of the dried out-group were made in January of 1983 and all four plants showed the usual central pith and primary wood cell area and in addition four growth rings. That is, they gave an apparent age of five and three quarters years.

Cross sections of two plants of each of the dried-out group were made in January of 1983 and all four them also showed the usual central area plus four growth rings! Several others, however, showed only three growth rings in addition to the central area, or gave their true age of four and three quarters years. Whether the ones which had the extra growth ring had responded to an unusually hot spell from July 2-19, 1982 cannot of course be determined, though they did make a much more rapid growth following this weather than in the long period of high fog in May and June.

Bristlecone pine seedlings growing in the ground do then respond to drying out and resumption of watering by forming an extra growth ring. The plants still remaining of each of the three groups will be given the same differential treatments next year in order to determine if drought treatment can cause extra ring formation on older, more mature plants.

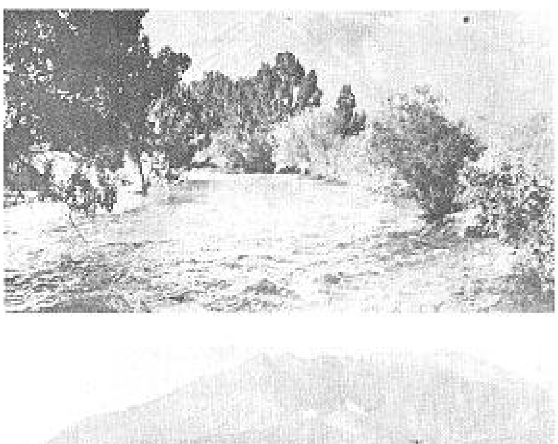

Figure 7. Upper: Rush Creek, Mono Lake's largest tributary stream, before diversions, ca. 1920. Photograph courtesy of Enid Larson. Lower: Rush Creek in 1981. Water diversions have turned the creek into a dry wash. Riparian woodlands, marshes, and meadows are gone. Photograph by David Strelnick.

This picture, and also Figure 8, are used here by courtesy of Fremontia.

Discussion

As pointed out in my article, "On the Recent Origin of the Pacific Southwest Deserts,"[3] the snowfields of the High Sierras were formerly much more extensive than now. Even as late as 1860 they were much larger as judged by the size of the King's and Kern rivers, according to Hittel.[4] Thus the King's River was 60 yards wide where it left the mountains. With extensive snowfields there would be much evaporation from them in the spring and early summer, as they melted and decreased somewhat in size until replaced by new snow in the winter. The prevailing westerly winds would carry this evaporation over the areas east of them as clouds giving rain to a limited extent, but much more than now, in the Owens River valley and the White Mountains.

An article in *Fremontia* entitled "Owens Valley and Mono Lake 1. Dying of Thirst" by David Gaines and Mary DeBecker[5] is most informative as regards former conditions in the Owens River valley. They say "With the spring snowmelt, numerous streams cascade down the steep eastern escarpment, flowing over immense alluvial fans that stretch down to the valley floor. Along the base of the alluvial fans, where downward percolating water is obstructed by claypans deposited in ice age Lake Owens, free-flowing artesian wells and springs supply marshes, sloughs, meadows and other moist habitats. . . . Over most of the valley floor, the water table ranges from the surface to less than fifteen feet in depth, i.e., within the root zone of grasses and shrubs. In the early 1900s the water table was less than four feet deep over 46% of the valley floor. But that was before the Los Angeles Department of Water and Power began extensive groundwater pumping." Now only remnants are left of the woodlands, marshes and meadows that once lined the banks of the Owens River. By 1928, deprived of water by the Los Angeles Aqueduct, Owens Lake had turned into glaring white alkali. Looking across its parched bed, clouds of dust rising from its surface, it is difficult to imagine steamboats plying its waters or millions of birds feasting along its shores. Figure 7 shows the comparison between Rush Creek, Mono Lake's largest tributary stream before diversions, ca. 1920; and after in 1981! Figure 8 shows the progressive shrinking of Mono Lake.

Though I had realized that this formerly lovely valley had suffered greatly as a result of the insatiable lust of the Los Angeles area for water, I had not realized until reading this article that the effect was either so bad or so recent.

Further back in history, Lake Bonneville (to consider another example) had an area of 50,000 square miles. Its decrease in size is correlated with a 200 year period of drought beginning about the year 1200 as determined by tree ring studies (actually probably later). Now, of course, it is known as the Great Salt Lake; and even since 1925 it has gotten smaller. Thus the big amusement palace built on its shore then is now one mile from it! Thus the decrease in rainfall

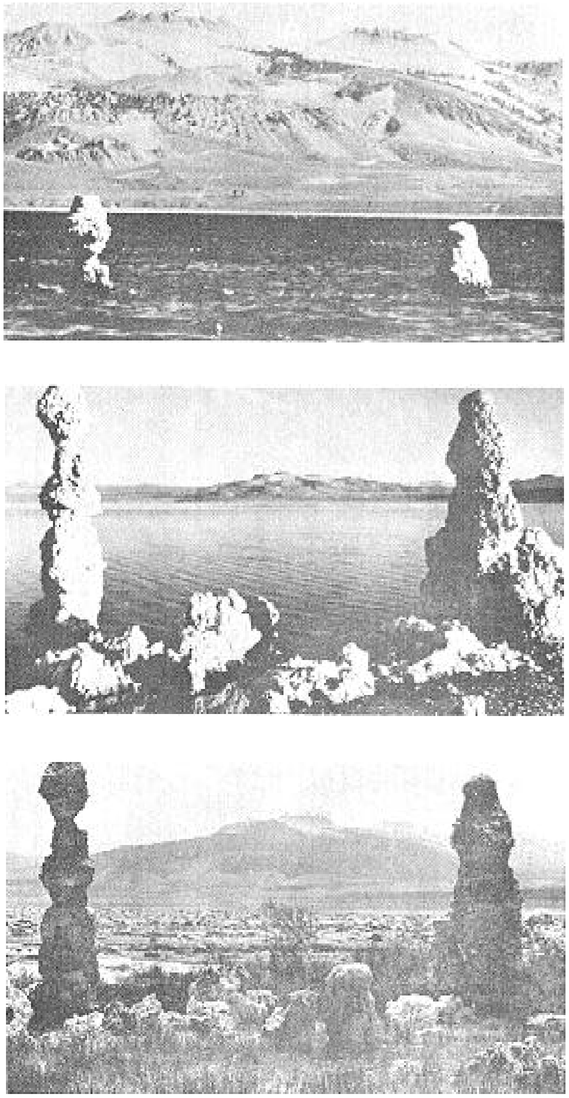

Figure 8. Progressive (or should one say retrogressive?) shrinking of Mono Lake is seen in the three pictures above showing the same tufa towers. Top picture was taken in 1962; center 1968; bottom 1978. The level of the water has fallen forty-six feet. Upper photographs by Eben McMillan; lower by Jim Stroup.

in such areas as the White Mountains is correlated with two phenomena: (1) the drying up of such great lakes as Bonneville, and (2) the decrease in size of the glaciers and snowfields. Water in a sense begets water; and as these lakes dried up the moisture became inadequate to form clouds and the rainfall on the more inland mountain areas decreased.

Prior to 1200, then, it would seem that such areas as the White Mountains had what is technically known as the San Francisco pattern of rainfall. As discussed by Waldo S. Clock and Sharlene R. Agerter in their chapter on “Rainfall and Tree Growth,,[6] in the book *Tree Growth,* in this pattern of rainfall a rainy season occurs in the winter and a dry season in the summer. (Figure 7, page 36, called California pattern in their discussion.) They discuss the effect this has on the problems of cross-dating and state: “the matter awaits careful study, especially in light of the fact that a second tip flush was observed to occur on conifers in August in the central Sierra Nevada at an elevation of 9,000 feet.”

Soil moisture is at an optimum in the spring, and then diminishes steadily to such an extent as often to halt growth. Then, as the high pressure builds up and the heat increases, even more stress has to be endured by the young pine forests. In the early fall, however, evaporation from the formerly existing large lakes again results in clouds and early fall rains even in such inland mountain areas as the White Mountains. The pine trees would then resume growth as Glock points out, with the result that another flush of growth and resultant growth ring occurs, just as in the experiment where the young seedlings formed an extra growth ring following return into the ground under the mist system after their drying out.

In the spring the hot sun and increasingly long days would act the same as the heat lamp treatment, only more so, and stimulate growth of the pine trees, especially in June and July, thus causing them greatly to extend their root systems. This would make them even more vulnerable to stress resulting in cessation of growth until the early fall rains.

As regards the question as to whether older trees would react in the same way as young seedlings, the experiments of James W. Hanover are pertinent. In his article, “Control of Tree Growth,“[7] his experiments show that shoot growth in seedlings of typical single-flush species will remain in the steady state of growth if given long periods of light (18-24 hours). That is, growth is continuous, and this occurs only in seedlings under three years of age. After three years the seedlings become locked into an endogenous system of plant growth. That is, even though they are exposed to long days and high temperatures, growth ceases, bud scales develop, and a resting bud forms. Only in the fall in response to both chilling and greatly increased moisture is a new cycle of growth resumed. This sort of situation no doubt occurred frequently in the past; a preliminary drop in temperature accompanied the first fall snow followed by hot late fall weather.

Now of course even the seedlings placed in the ground and responding to drying out by forming an extra growth ring were only three and three quarters years old. They would therefore behave as mature trees, as determined by Hanover. His Figure 5, mature tree, three years plus behavior illustrates this. Accordingly it would seem that the results obtained by drying them out would also apply to older trees.

In the three thousand years or so from the end of the Flood until 1100 A.D. there would then have been an opportunity for the formation of many extra rings. It would seem that they would be fully comparable to those formed in the spring and so difficult if not impossible to detect. For as shown in Figure 6 the extra ring has a very similar diameter and might well have been formed during a regular but relatively dry growing season. J. L. Giddings in his article “Development of Tree-Ring Dating as an Archeological Aid”[8] in *Tree Growth,* claims that false annual rings can be detected because of the ability to retain a mental image of typical ring patterns or "signatures." Though this is correct, the very basis of these "signatures" is the concept that in the past climatic conditions were essentially the same as now. This, as we have shown, was certainly not the case. Therefore it is our belief that the 7100 years which such men as Ferguson claim have been attained by some of the bristlecone pine trees may actually be only about 5600 years, assuming that extra rings are formed about 50% of the years since the end of the Flood due to summer stresses.

Much further work needs to be done on such questions as how the pine forests got started in the White Mountains in the first place. The species is found also in the mountains of Colorado, where it varies only slightly from the White Mountain strain, and in northern Arizona. Which area is its primary location? Also we need to know more about rainfall patterns in the past, and just when such areas as the Owens River valley became so desert-like. As judged by the citation from *Fremontia* it would seem to be much more recent than is usually assumed by Flood geologists. Experiments need to be continued on the older seedlings yet remaining to see how they will react to both continuous irrigation and to drying out. Finally, a new crop of seedlings has been germinated as of February 10, 1983 in order to try cold storage treatments again, using the short day, low temperature treatment following high temperature, long day growth as reported by Hanover.

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Summary

Various treatments were given to 8 month old bristlecone pine seedlings and it was found that supplementing the winter day length with a 250 watt heat lamp to give 16 hours of illumination proved most effective. The lamp was placed about three feet above the seedlings.

When two-year-old seedlings were given the stress of a three week period of not watering them when in pots on the greenhouse bench and then replaced in the ground to pot level under a mist system, they resumed growth in late August and continued growth until late in September. When cross sections of these were made in December of 1981 it was found that they showed four growth rings as compared to the usual three of untreated seedlings.

Also three year old seedlings were given a two week period of drying out from August 3 until August 18, 1981. These also resumed growth when replaced under the mist system. These also showed four growth rings when examined by making cross sections in December of 1981.

Furthermore, when set out in the ground in January of 1982, kept continuously moist until August 31, 1982 and then given a 23 day stress period before resumption of irrigation these seedlings also showed an extra growth ring.

The bearing of this on the estimates of the age of the bristlecone pine made by Ferguson and others is pointed out. Under the San Francisco or California pattern of rainfall with a dry period in the summer the young forests on the White Mountains would have grown an extra ring per year quite often also. This would be in response to a sudden lowering of temperature after an early fall rain or possibly snow and then resumption of hot growing weather. Accordingly it is believed that the presumed 7100 years of age postulated for these trees by Ferguson would be reduced to about 5600 years, on the assumption that extra rings would be formed by effects of stress during about 50% of the approximately three thousand years since the end of the Flood.

The need for further study of the effect of drying out on older trees is pointed out. Also such questions as just when the Owens River valley became so desert-like need to be investigated.

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QUOTABLE QUOTE

". . . my simple art . . . is but systematized common sense . . . when you have eliminated all which is impossible, then whatever remains, however improbable, must be the truth. It may well be that several explanations remain, in which case one tries test after test until one or other of them has a convincing amount of support."

Sherlock Holmes, in the story *The Adventure of the Blanched Soldier.*

Is this not a simple statement of the principles about which so much has been written as the scientific method?