VARIATION in SEEDS and OVULATE CONES of Some SPECIES and VARIETIES of CUPRESSUS

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SUMMARY

Variation in seeds and ovulate cones from 19 stands of *Cupressus,* including all species and varieties native to the United States, were evaluated. Cones and seeds were collected from 3 to 15 trees of each geographic source. All varieties and geographic sources of *Cupressus arizonica* except var. *stephensonii* were analyzed as a group separately from other species and varieties.

Seed weight and cone weight increased from south to north in *Cupressus arizonica* and decreased from south to north in the California *Cupressus* group. In both groups some species and varieties can be distinguished from others on the basis of seed and or cone weight.

Differences between sources for scales per cone were slight for *Cupressus arizonica,* but were definitive for some of the California group.

Information on percentage of filled seed and color of seed is presented.

Correlations indicate that the larger cones normally possess the largest seeds, have more scales, and contain a higher percentage of filled seeds.

Variation within and between sources is discussed.

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Variation in Seeds and Ovulate Cones of Some Species and Varieties of Cupressus

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GEOGRAPHIC VARIATION in many tree species has long been recognized. Managers of forest land must, therefore, be cognizant of the variation present in the species that they utilize.

Variation in *Cupressus* is of interest because of the many species and varieties growing throughout a wide range of geographically isolated habitats. If individuals or populations are different from locality to locality, the difference can only be attributed to environmental differences and genetic variation. Genotypes that are best suited to a given habitat will survive and reproduce; thus, if localities are characterized by different environments and if reproductive isolation is present, genetic variation will occur.

Information on variation in seeds and cones of *Cupressus* is important to a seed purchaser because in some cases the origin of seed bought from a commercial dealer may be verified based upon knowledge of variation. Variation in seeds and cones may also provide quantitative information that would help taxonomists in classification of species or varieties. Commercial seed suppliers need information on seeds per pound so that they can more accurately satisfy the specifications of the seed purchaser. Nurserymen also need data on seed size for use in estimating quantity of seed needed and regulating sowing rates.

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REVIEW OF LITERATURE

Geographic variation is prevalent, although not always present, in forest trees. Langlet *(7)* summarized much of the early work. Several recent publications include brief reviews of past work: Dorman *(4)*, Echols *(5)*, Callaham *(3)*, Langlet *(8)*, and Squillace *(12)*.

Literature concerning geographic variation in seed and cone characteristics of *Cupressus* is absent. The only information concerning seed and cone size for each species is that by Wolf and Wagener *(21)*. The Yearbook of Agriculture *(2)* gives the weight and percentage of germination of *Cupressus arizonica* seed, but the seed source is not given. The Woody Plant Seed Manual *(1)* provides data on number of seeds per pound for three species of *Cupressus*, but the seed source is not mentioned.

In *Cupressus* ovulate cones mature in two seasons and in most species remain closed on the tree for several years. On individual trees closed cones may persist for as long as 10 years. Wolf and Wagener *(21)* state that seeds remain viable in the closed cones, but recent research at Auburn University (unpublished) indicates that as age of cone increases seed viability decreases.

One would expect seed size to have a high survival value in natural selection. On moisture deficient soils, large seed should have a greater chance of survival than small seed because of greater food reserves. Wells *(20)* working with *Pinus ponderosa* Laws., found that seeds from areas with a warm climate, long growing season, or low precipitation were largest. The smallest seeds came from areas with a cold climate and a short growing season. This pattern of variation agrees with Toumey *(17)* who stated that conifers from low spring rainfall areas tend to have large seed. Wright *(22)* indicated that trees in moist site populations are usually smaller seeded than dry site populations.

The effects of altitude of seed source on seed size in *Larix decidua* Mill. were reported by Thulin and Miller *(16)*. They found, after examination of 26 provenances, that seed size increased with an increase in altitude. Thorbjornsen *(15)* reported that in loblolly pine seed length showed random variation. The existence of random variation would indicate the absence of selection pressure on seed length. In slash pine (*Pinus elliottii* Engelm) seed weight was lowest in a northeast-southwest trough that occurred in southeast Georgia. Seed weight increased in all directions from the trough then decreased irregularly to the south.

Variation in seed weight between mother trees was extremely large, 10 to 51 milligrams per seed, Squillace *(12)*. In general, for widespread species, the largest seeds occur in the southern portion of the range and the smallest seeds occur in the northern portion, Wright *(22)*. This pattern may not be evident if only a portion of a range is considered or if environmental differences within the species range are not great.

Literature concerning variation in cone size is limited. In sugar pine (*Pinus sabiniana* Dougl.) Griffin *(6)* found no simple correlations of latitude, temperature, precipitation, or other habitat factors with cone size. Random variation for cone length exists in loblolly pine according to Thorbjornsen *(15)*. In his studies of slash pine cone length, Squillace *(12)* found that most of the variation was associated with mother trees within stands. He also found that length of cones increased from southeast Florida to Georgia then decreased slightly. Cones of spruce from 35 stands decreased in weight from optimal sites to high alpine sites, Surber *(14)*.

MATERIALS AND METHODS

Taxonomic literature on *Cupressus* has been somewhat confused. In their book on new world cypresses, Wolf and Wagener *(21)* accepted 15 species, 1 with 2 subspecies. Wolf's classification of species rests on rather insecure morphological features; in fact, Wolf states that there are few single characteristics in *Cupressus* so constant or important that they can be relied upon to differentiate species. It is the authors' intention to follow the taxonomic treatment given by Little *(9,10)*.

During the summer of 1964, a collection trip was made throughout Southwestern United States. The immediate objectives were to study natural stands of as many species and varieties of *Cupressus* as feasible and to collect seeds and cones from each grove

visited. Seeds and cones from the following species and varieties were sampled:

Species	Location of Grove	
Cupressus arizonica Greene var. *arizonica*	1	Big Bend National Park, Brewster Co., Texas
Cupressus arizonica Greene var. *arizonica*	2	Devils Canyon, Chihuahua, Mexico
Cupressus arizonica Greene var. *arizonica*	3	Chiricahua National Monument, Cochise Co., Arizona
Cupressus arizonica Greene var. *arizonica*	4	Greenlee County, Arizona
Cupressus arizonica Greene var. *arizonica*	5	Cochise Stronghold, Arizona
Cupressus arizonica Greene var. *arizonica*	7	Bear Canyon, Pima Co., Arizona
Cupressus arizonica Greene var. *arizonica*	20	Graham County, Arizona
Cupressus arizonica Greene var. *glabra* Sudw.	8	Oak Creek Canyon, Arizona
Cupressus arizonica Greene var. *glabra* Sudw.	9	Gila County, Arizona
Cupressus arizonica Greene var. *nevadensis* Abrams	19	Kern County, California
Cupressus arizonica Greene var. *stephensonii* Wolf	11	Cuyamaca Peak, San Diego Co., California
Cupressus guadalupensis S. Wats.	10	Guatay Mountain, San Diego Co., California
Cupressus sargentii Jeps.	12	Cypress Creek, Monterey Co., California
Cupressus macrocarpa Hartw.	13	Monterey County, California
Cupressus goveniana Gord.	14	Santa Cruz County, California
Cupressus goveniana Gord. var. *pygmaea* Lemm.	15	Mendocino County, California
Cupressus bakeri Jeps.	16	Siskiyou County, California
Cupressus bakeri Jeps.	17	Shasta County, California
Cupressus macnabiana A. Murr.	18	Amador County, California

Figure 1 is a map of Southwestern United States showing locations of *Cupressus* groves sampled. Further descriptions of location, elevation, rainfall, aspect, and general characteristics of each grove visited are given by Posey and Goggans *(11)*.

One of the objectives of this study was to determine the range of variation in several characteristics for the genus; therefore, in each grove trees were selected so that the total phenotypic variation present would be represented. For all geographic sources of *Cupressus arizonica* except var. *stephensonii* cones were collected from 11 to 15 mother trees in each locality. In all other species and varieties studied, including *Cupressus arizonica* var. *stephensonii*, cones were collected from 3 to 5 mother trees at each locality. Where feasible, sample trees within sources were at least 200 feet apart to minimize selection of siblings. To obtain sufficient seed cones were collected regardless of age. In some instances cones 10 years of age were utilized. The 100 to 300 cones col-

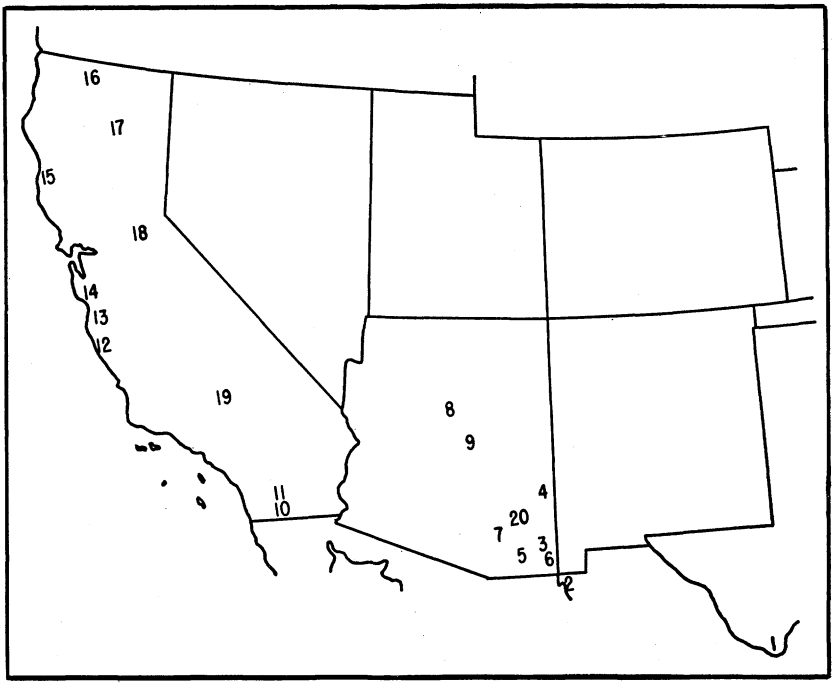

FIGURE 1. This map of Southwestern United States shows the locations of Cupressus groves sampled.

lected per mother tree were kept separate by trees so that one-parent progeny tests could be conducted and variation between trees in sources and within trees could be determined.

Cones were allowed to dry at room temperature until they opened, and seed were then extracted. The cones were then put into cloth bags and stored in a dry, warm room for several months. One hundred cones per mother tree were chosen and weighed to the nearest gram. Twenty-five cones were chosen at random from each mother tree and the scales per cone were counted.

The seed from each mother tree were kept separate and stored in sealed glass jars until used. After thorough mixing, 1,000 seeds were taken per mother tree and weighed to the nearest .01 g. as a measure of seed size. Two hundred seeds were selected at random from each mother tree and cut to determine per cent filled seed. Amount of glaucous covering on seed and color of seed were observed for each seed lot.

Analyses of variance were used to test for differences within trees, between trees in geographic sources, and between geo-

graphic sources for the number of scales per cone. Differences between trees in geographic sources and between geographic sources were tested for weight of seed, per cent filled seed, and cone weight. Covariance analyses were made to test for the effect of latitude and elevation upon each of the four mentioned variables. All meaningful simple correlation coefficients between all variables were also calculated. The significance of correlations was determined after Z transformation followed by calculation of t.

For analyses the data were divided into two groups because of differences in intensity of sampling and because of major differences in environmental variables. One group (Arizonica group) included 10 localities of all varieties of *Cupressus arizonica* except variety *stephensonii.* Samples were taken from 11 to 15 mother trees in each locality. The other group (California) included 9 sources of 7 species and varieties native to California. Information for seed weight and cone weight is presented separately for each group.

It should be understood that data presented cannot be used to distinguish species or varieties when compared with a single cone or only a few seeds. For example, *Cupressus macrocarpa* can be distinguished from all other species studied based upon number of scales per cone. The range of scales per cone based upon individual cones for *Cupressus macrocarpa* is 6 to 14. Cones with 6 scales per cone can be found in all other species. It is only when the data are observed as scales per cone averages by mother trees that differences between species, varieties, and geographic sources become evident.

Some of the conclusions may be of limited value because in some species only one geographic source was sampled and in the California group only a few trees per source were sampled.

RESULTS AND CONCLUSIONS

Seed Weight (Arizonica Group)

The weight of 1,000 seeds used as a measure of seed size increased from south to north. A correlation of .48, significant at the 1 per cent level, existed between latitude and weight of 1,000 seeds. This pattern of increase in seed size from south to north is opposite that indicated by Wright *(22),* but can be explained by the fact that the high elevation collection points were in the south and elevation of collection points decreased with an increase in

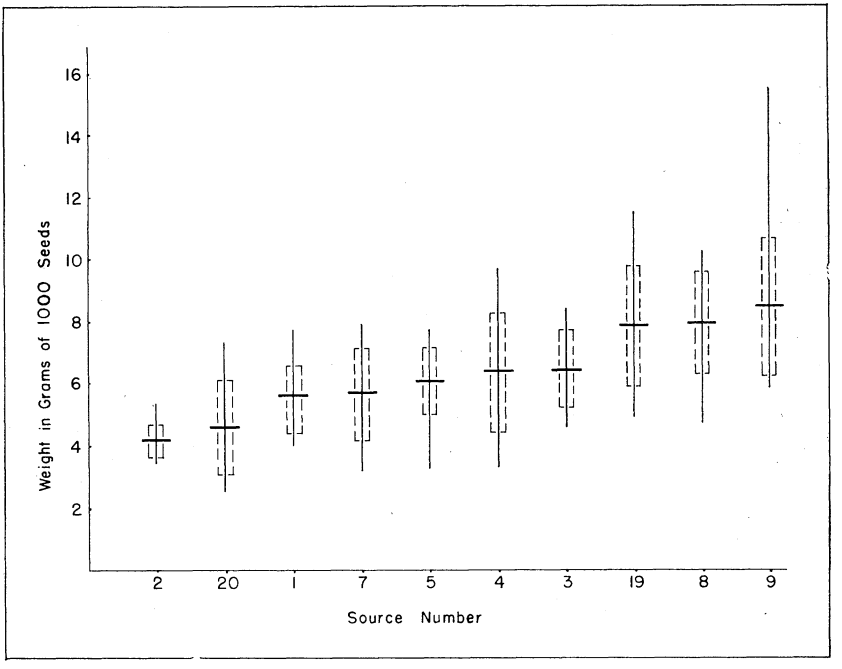

FIGURE 2. Range, mean, and standard deviation of seed weight for sources of Cupressus arizonica. (Vertical line represents range of data, boxed in portion standard deviation, and horizontal line the mean.)

latitude. Variation in seed weight for *Cupressus arizonica* follows the same pattern as reported for ponderosa pine by Wells *(20)* where seed from areas with warm climates, long growing seasons, or low preciptation were largest.

The range, mean, and standard deviation of seed weight for sources of *Cupressus arizonica* are presented in Figure 2. Seed weight between sources ranged from an average of 4.2 grams per 1,000 seeds for *Cupressus arizonica* var. *arizonica* from Chihuahua, Mexico to 11.1 grams per 1,000 seeds for *Cupressus arizonica* var. *stephensonii*[1] from Cuyamaca Peak, California. The largest seed of *Cupressus arizonica* var. *arizonica* from Chihuahua, Mexico weighed 5.3 grams per 1,000 seeds whereas the smallest seed of *Cupressus arizonica* var. *glabra* from Gila County, Arizona weighed 5.9 grams per 1,000 seeds. The fact that the seed weights of the two populations did not overlap would indicate the possibility of distinguishing the two sources based upon seed weight.

[1] See Figure 3 for this variety.

Within *Cupressus arizonica* the different geographic sources and varieties can be divided into four ecotypes based upon seed weight.

1. *Cupressus arizonica* var. *arizonica* from Devils Canyon, Chihuahua, Mexico, and from Graham County, Arizona, averaging from 4.2 to 4.6 grams per 1,000 seeds.

2. *Cupressus arizonica* var. *arizonica* from Big Bend National Park, Texas; Bear Canyon, Arizona; Cochise Stronghold, Arizona; Greenlee County, Arizona; and Chiricahua National Monument, Arizona; averaging from 5.7 to 6.4 grams per 1,000 seeds.

3. *Cupressus arizonica* var. *nevadensis* and var. *glabra* ranging from 7.9 to 8.5 grams per 1,000 seeds.

4. *Cupressus arizonica* var. *stephensonii* averaging 11.1 grams per 1,000 seeds is the largest seeded variety of *Cupressus arizonica.*

For all geographic sources and varieties of *Cupressus arizonica,* variation in seed weight between mother trees within a source accounted for a significant portion of the total variation. *Cupressus arizonica* var. *arizonica* from Chihuahua, Mexico, had the least variation in seed weight and *Cupressus arizonica* var. *glabra* from Gila County, Arizona, exhibited the greatest variation between trees for seed weight.

The cypress stand in Chihuahua, Mexico, was the smallest population studied and it occurred in a well protected canyon. In comparison, the population of cypress in Gila County, Arizona, is large and the trees occur in open areas. Differences in the amount of variation among mother trees between geographic areas may be a function of population size and environmental factors. One would suspect that a small population in a protected habitat would exhibit less variation between trees than would a large population subjected to great annual variation in environmental conditions.

Seed Weight (California Group)

Variation patterns between species and varieties of *Cupressus* native to California are different from the observed pattern for *Cupressus arizonica.* For cypresses of California, seed weight decreases with an increase in latitude. This is opposite that of *Cupressus arizonica,* but can be explained by the fact that there was no constant relationship between latitude and elevation of cypress groves studied in California. There was also no constant relationship between weight of seed and elevation of collection points.

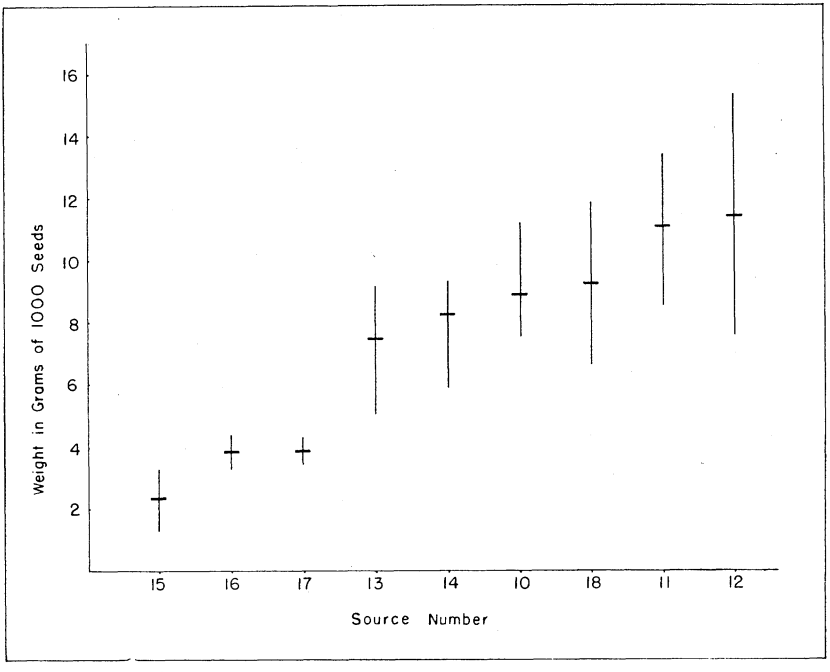

FIGURE 3. Range and mean for seed weight of Cupressus native to California. (Vertical line represents range of data and horizontal line the mean.)

The range and mean of seed weight for the California group are presented in Figure 3. The data were analyzed by use of Duncan's new multiple-range test, Steel and Torrie *(13)*. Results indicate that *Cupressus goveniana* var. *pygmaea* and *Cupressus bakeri* from Siskiyou and Shasta Counties, California can be distinguished from all other sources based on seed weight. Weight of 1,000 seeds for these three sources averaged from 2.3 to 3.8 grams whereas all other sources averaged from 7.5 to 11.4 grams. *Cupressus goveniana* var. *pygmaea* had the smallest seed (2.3 grams per 1,000 seeds) while *Cupressus sargentii* from Cypress Creek, California had the largest seed (11.4 grams per 1,000 seeds).

The range of seed weight for *Cupressus goveniana* var. *pygmaea* and *Cupressus bakeri* from Siskiyou and Shasta Counties, California does not overlap with the range of seed weight for *Cupressus arizonica* var. *arizonica* from Chiricahua National Monument, Arizona, *Cupressus arizonica* var. *glabra* from Oak Creek Canyon and Gila County, Arizona, and *Cupressus arizonica* var. *nevadensis* from Kern County, California. This indicates that two of these species, varieties or sources may be differentiated by seed

weight if each of the two being compared occur in a different group.

Data for seed weight converted to number of seeds per pound for each source are presented in the table.

NUMBER OF SEEDS PER POUND BY SPECIES, VARIETIES, AND GEOGRAPHIC SOURCES

Source number	Arizonica group Species	Location	Seed per pound Low	Average	High
No.			*No.*	*No.*	*No.*
2	*Cupressus arizonica* var. *arizonica*	Devils Canyon, Chihuahua, Mexico	84,700	108,300	131,900
20	*Cupressus arizonica* var. *arizonica*	Graham County, Arizona	61,600	97,700	176,200
1	*Cupressus arizonica* var. *arizonica*	Big Bend National Park, Texas	58,600	79,800	111,500
7	*Cupressus arizonica* var. *arizonica*	Bear Canyon, Pima County, Arizona	56,800	79,100	141,800
5	*Cupressus arizonica* var. *arizonica*	Cochise Stronghold, Arizona	58,400	74,600	138,000
4	*Cupressus arizonica* var. *arizonica*	Greenlee County, Arizona	46,900	70,900	136,800
3	*Cupressus arizonica* var. *arizonica*	Chiricahua National Monument, Arizona	54,000	70,600	98,500
19	*Cupressus arizonica* var. *nevadensis*	Kern County, California	39,400	57,500	91,400
8	*Cupressus arizonica* var. *glabra*	Oak Creek Canyon, Arizona	44,200	57,000	95,600
9	*Cupressus arizonica* var. *glabra*	Gila County, Arizona	29,600	53,100	63,900
11	*Cupressus arizonica* var. *stephensonii*	Cuyamaca Peak, San Diego County, California		40,900	
	California group			Average *No.*	
15	*Cupressus goveniana* var. *pygmaea*	Mendocino County, California		194,600	
16	*Cupressus bakeri*	Siskiyou County, California		118,900	
17	*Cupressus bakeri*	Shasta County, California		118,600	
13	*Cupressus macrocarpa*	Monterey County, California		60,400	
14	*Cupressus goveniana*	Santa Cruz County, California		56,300	
10	*Cupressus guadalupensis*	Guatay Mountain, California		51,000	
18	*Cupressus macnabiana*	Amador County, California		49,000	
12	*Cupressus sargentii*	Cypress Creek, California		39,300	

Cone Weight (Arizonica Group)

Air dry weight of cones followed the same pattern as seed weight. Within *Cupressus arizonica* cone size increased from south to north and there was a negative correlation, significant at the 5 per cent level between cone weight and elevation.

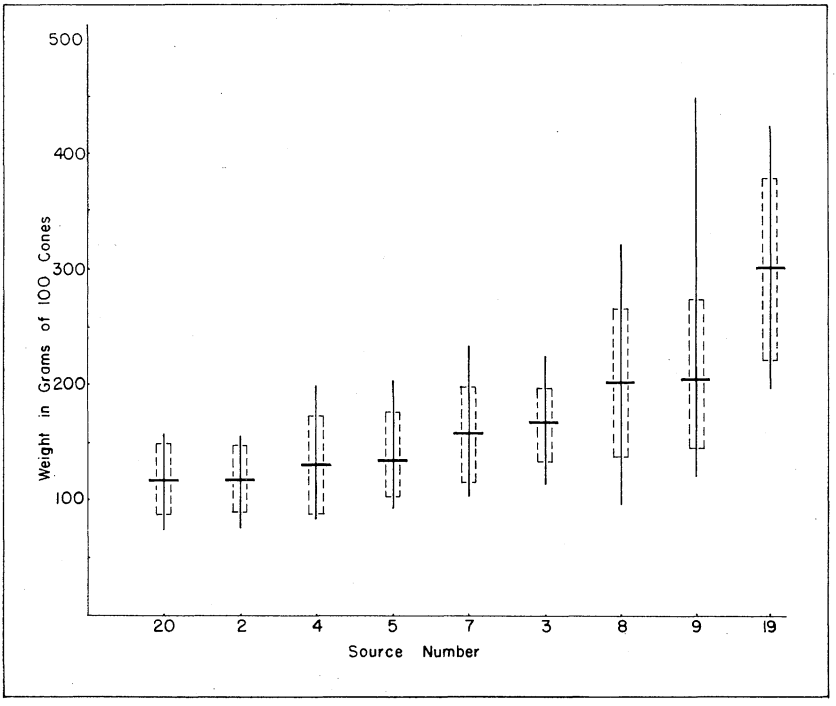

FIGURE 4. Range, mean, and standard deviation of cone weight for sources of Cupressus arizonica. (Vertical line represents range of data, boxed in portion standard deviation, and horizontal line the mean.)

The range, mean, and standard deviation of cone weight for sources of *Cupressus arizonica* are presented in Figure 4.

Cones representing cypress from Big Bend National Park, Texas, were not included in the comparison because of cutting for seed extraction. Of those compared, *Cupressus arizonica* var. *arizonica* from Graham County, Arizona, had the smallest cones and *Cupressus arizonica* var. *stephensonii*[2] had the largest, being 2.8 times heavier.

In *Cupressus arizonica* the range of cone weight within the Graham County, Arizona source and the Chihuahua, Mexico source does not overlap the range of cone weight for *Cupressus arizonica* var. *stephensonii* and *Cupressus arizonica* var. *nevadensis*, indicating that two of these sources could be distinguished on basis of cone weight if each of the two being compared occurred in a different group.

[2] See Figure 5 for this variety.

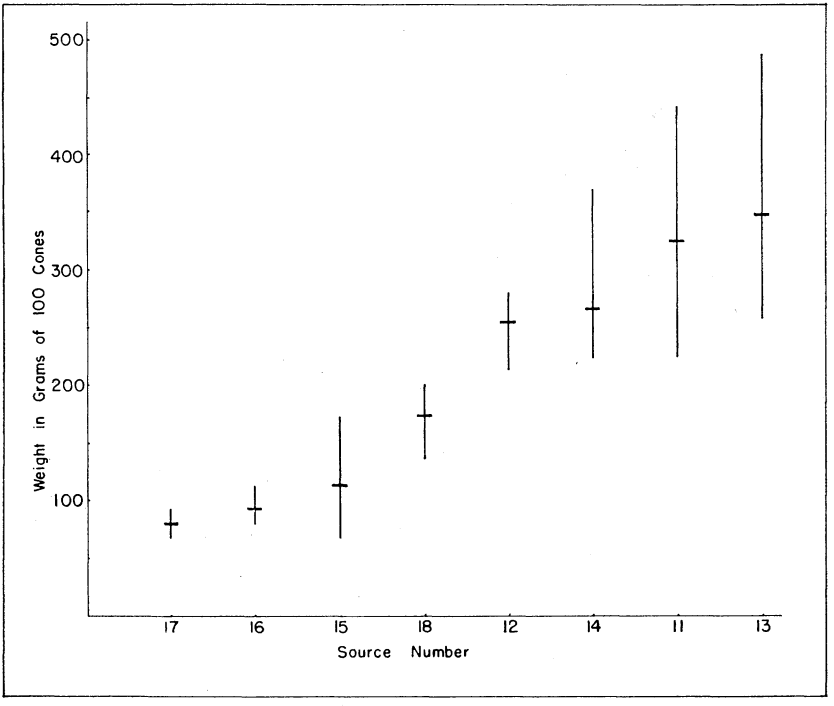

FIGURE 5. Range and mean of cone weight of Cupressus native to California. (Vertical line represents range of data and horizontal line the mean.)

Variation in cone weight between mother trees within sources was greatest in *Cupressus arizonica* var. *glabra* from Gila County, Arizona, and least in *Cupressus arizonica* var. *arizonica* from Chihuahua, Mexico. This is the same pattern that exists for seed weight.

Cone Weight (California Group)

In species of *Cupressus* native to California, cone weight follows the same pattern as seed weight i.e., cone weight decreases from south to north. For cone weight, there is a slight but nonsignificant trend for a decrease with an increase in elevation. The range and mean of cone weight for *Cupressus* native to California are presented in Figure 5.

Cupressus bakeri from Shasta County had the smallest cones and *Cupressus macrocarpa* from Monterey County had the largest. The following species, varieties, and sources can be distin-

guished on the basis that their ranges of cone weights do not overlap:

1. A group consisting of *Cupressus bakeri, Cupressus governiana* var. *pygmaea,* and *Cupressus macnabiana* can be distinguished from a group consisting of all other California species.

2. *Cupressus bakeri* can be distinguished from all other California species and varieties except *Cupressus goveniana* var. *pygmaea.*

3. *Cupressus bakeri* and *Cupressus goveniana* var. *pygmaea* can be distinguished from *Cupressus arizonica* var. *nevadensis.*

4. A group consisting of *Cupressus arizonica* var. *stephensonii, Cupressus sargentii, Cupressus macrocarpa,* and *Cupressus goveniana* (Santa Cruz County) can be distinguished from a group consisting of *Cupresus arizonica* var. *arizonica* from Graham County, Arizona; Chihuahua, Mexico; Greenlee County, Arizona; and Cochise Stronghold, Arizona.

5. *Cupressus macrocarpa* can be distinguished from all sources of *Cupressus arizonica* var. *arizonica.*

Scales Per Cone

Variation in number of scales per cone between all varieties and sources of *Cupressus arizonica* was slight. Average scales per cone by sources is shown in Figure 6. There was not enough variation in scales per cone to be of diagnostic value.

Variation in number of scales per cone between species native to California was significant. The average number of scales per cone for species of *Cupressus* native to California is shown in Figure 7. *Cupressus macrocarpa* averaged nine scales per cone; more than any other species or variety. *Cupressus macnabiana* averaged 5.4 scales per cone; fewer than any other species or variety.

On the basis of scales per cone, the following delineations can be made:

1. *Cupressus macrocarpa* can be distinguished from all other *Cupressus* native to the United States.

2. *Cupressus macnabiana* can be distinguished from *Cupressus macrocarpa, Cupressus goveniana* var. *pygmaea,* and from *Cupressus goveniana.*

For *Cupressus arizonica* there was no correlation between latitude or elevation and scales per cone. In species of *Cupressus* native to California, there was a slight but non-significant trend

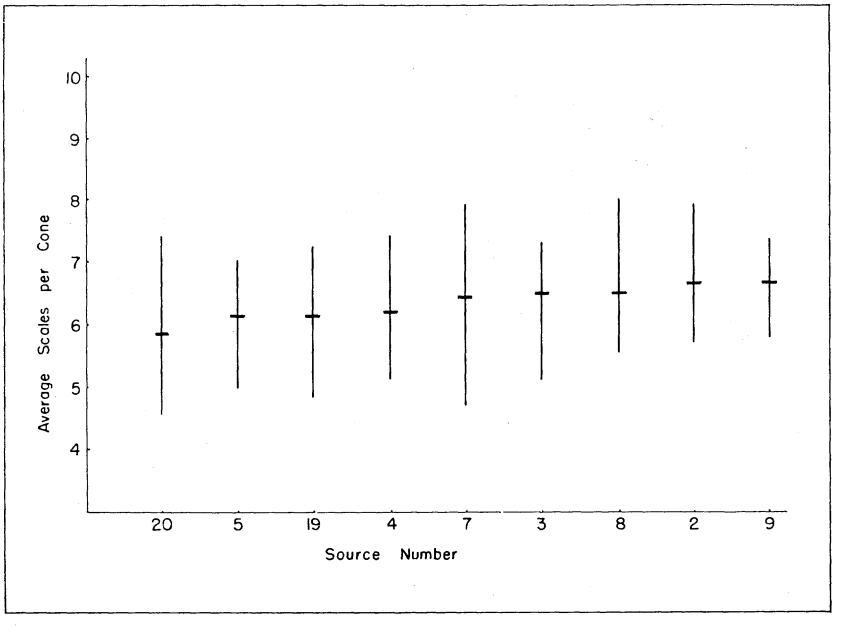

FIGURE 6. Average scales per cone for geographic sources of Cupressus arizonica. (Vertical line represents range of data and horizontal line the mean.)

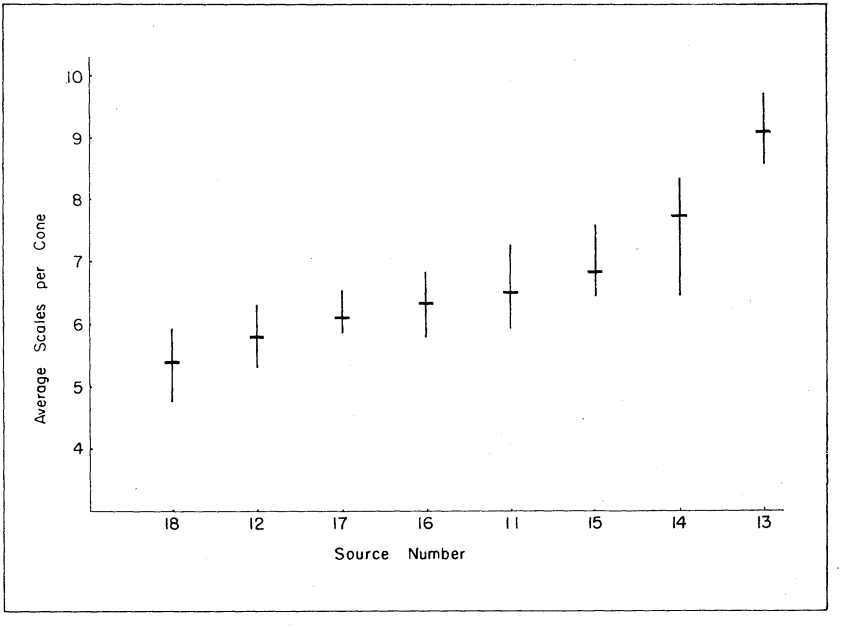

FIGURE 7. Average scales per cone for Cupressus native to California. (Vertical line represents range of data and horizontal line the mean.)

for scales per cone, a decrease from south to north. A negative correlation between elevation and scales per cone, significant at the 5 per cent level, was present in the California group.

Cupressus guadalupensis was not included in the comparison because the cones were destroyed during seed extraction.

Per Cent Filled Seed

In *Cupressus arizonica* and in *Cupressus* native to California, there was no constant relationship between latitude or elevation and the per cent of filled seed. *Cupressus arizonica* var. *arizonica* from Chiricahua National Monument, Arizona, had the highest average per cent filled seed (29 per cent) whereas, the same variety from Cochise Stronghold, Arizona, had the lowest amount of filled seed (10 per cent). The range of per cent filled seed for all trees of *Cupressus arizonica* from all sources was from 1 per cent to 49 per cent.

Per cent filled seed in California ranged from a high of 32 per cent in *Cupressus guadalupensis* to a low of 16 per cent in *Cupressus sargentii.*

Seed Color

Quantitative data on seed color were not obtained; however, some interesting observations were made.

Cupressus macrocarpa and *Cupressus goveniana* var. *pygmaea* were the only species having black seed. The light tan seed of *Cupressus bakeri* were the lightest in color of all species and varieties studied. All *Cupressus* studied except *Cupressus guadalupensis, Cupressus stephensonii,* and *Cupressus goveniana* var. *pygmaea* had some trees with glaucous seed. In *Cupressus arizonica* var. *glabra* and var. *nevadensis* all seed from all study trees were glaucous.

Correlations Between Traits

In *Cupressus arizonica* the following relationships were evident. (Significance denoted by asterisk; 5 per cent level*; 1 per cent level**.)

1. The larger the cones the greater the number of scales per cone.*

2. The largest cones normally possess the largest seed**, thus indicating, according to Vacaru and Lalu *(19)* that for higher germinative capacity it would probably be better to collect only the largest cones.

3. Large cones generally possess a higher per cent of filled seed than small cones*, indicating an additional reason to use only the larger cones.

Relationships between traits for *Cupressus* studied in California are as follows:

1. The largest cones had the greatest number of scales per cone.**
2. The largest seed are normally found in the largest cones.**
3. There was no constant relationship between weight of cones and per cent of filled seed.
4. There was also no constant relationship between weight of seed and per cent of filled seed.

Evolutionary Trend

From the evolutionary standpoint, a significant aspect of *Cupressus* is the tremendous amount of variation in most morphological characteristics within and between sources. Since the cypresses occur only in relatively small groves in a few protected habitats that are usually widely separated geographically from other groves, one would expect *Cupressus* to be an old genus with little variation and little ability to evolve further. This, however, is not completely true because there is much variation between trees in groves and between groves.

The variation between groves can be a result of environmental differences between geographic areas. These environmental differences over many generations would tend to cause genetic changes in the population. Part of the variation within groves may be caused by the extreme year-to-year environmental differences. Some genotypes could have a selective advantage in good years and other genotypes an advantage in poor years.

In a few of the groves particularly where population size and variation between trees is limited the species does not appear to be able to evolve fast enough to meet the demands of a changing environment.

It was stated by Wolf and Wagener *(21)* that the present day *Cupressus* groves are remnants of a once widespread distribution. Twisselmann *(18)* suggested that *Cupressus arizonica* var. *nevadensis* is a remnant of a once widespread complex in the arid woodland occurring across the Mojave Desert until late Pliocene. If one considers the isolation of most groves and the present variation patterns in *Cupressus,* it is not difficult to see how there may have been one widespread species throughout the Southwest. En-

vironmental conditions changed faster than the species could evolve to meet the challenges of a new environment; thus the species has retreated to a few small environmental niches still suitable for growth and reproduction. A decrease in population size, geographic isolation, and different selection pressures have produced enough variation between groves so that some groves are now classified as different species.

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