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Genetic Variation Among Five Giant Sequoia Populations

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Summary

Rooted cuttings from five giant sequoia populations from the southern part of the species' range were planted in four blocks at a nursery in Moscow, Idaho. Significant genetic variation was found between populations in growth, crown form, patterns of cold acclimation, and cold hardiness, but not in phenology. Block effects were also strong. Six individuals were identified as potentially adapted to the planting site. Additional testing of these genotypes should be conducted on a broad range of sites in the future.

Key words: Giant sequoia, populations, cold hardiness, genetic variation, adaptation.

Introduction

Giant sequoia (*Sequoiadendron giganteum* [Lindl.] Buchholz) is a popular ornamental in the United States, Europe, and Asia (Muri, 1978; Libby, 1981), although its current native range is restricted to a narrow strip (418 km long and no more than 24 km wide) on the west slopes of Sierra Nevada Mountains in California. Despite its broad popularity, few studies of population variation in this species have been reported in the literature.

Genetic variation among trees from different origins can be an especially important consideration when introducing a species as an exotic, particularly for characteristics that influence early survival. The few provenance studies that have been established with giant sequoia have demonstrated the existence of genetic variation among its populations. Guinon *et al.* (1982) found significant variation in frost resistance, winter damage and early height among two-year-old giant sequoia seedlings, which were sampled from 22 provenances grown in Escherode, West Germany. Fins (1979) and Fins and Libby (1982) found genetic variation in seeds and seedling characteristics among giant sequoias sampled from 34 native populations. Mahalovich (1985) found small but significant differences between populations in early growth, and larger differences in crown shape and basal taper in young trees planted at Foresthill, California. And Melchior and Herrmann (1987) found significant differences in height, diameter at breast height and diameter at half height between four provenances of 14-year-old giant sequoias planted on three sites in West Germany. At the Rengsdorf site, height growth was slightly negatively correlated with elevation of the source.

The purpose of this study was to identify populations and/or individuals of giant sequoia that are potentially well-adapted to environments in northern Idaho. The early winter of 1983—84 provided an excellent opportunity to assess the response of young giant sequoias to early cold temperatures, as well as their ability to recover from cold damage. We measured genetic variation among five provenances in growth, phenology, cold-hardiness and crown characteristics.

Materials and Methods

Study materials consisted of 174 rooted cuttings of giant sequoia from the Mountain Home, Garfield, Cedar Flat, Giant Forest and Whitaker populations, all in the southern part of the species' range. Cuttings were collected from one-year-old seedlings in October 1980, rooted during the winter of 1980—81, and planted in four blocks at a nursery site in Moscow, Idaho on June 31, 1981. A total of 200 cuttings were originally planted. All were in good to excellent condition at the time of planting. The plantation was watered during the first, second, and fourth summers. Survival was greater than 95% during the initial years of establishment, and dropped to 87% (174 trees) after the winter of 1983—84).

1. Phenological and growth traits

This phase of the study began in July 1984, and continued through spring 1985. Total height and fourth year elongation were measured weekly, and diameter was

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measured monthly from July until October 1984. Since the trees had already begun growth when the study was started, information on the time at which growth began in 1984 was not obtained. The dates on which growth began in spring 1985 were recorded by observing terminal branches weekly.

2. Crown characteristics

We measured average branch angle from the bole, widest crown diameter, and crown form. Average branch angle was measured on four randomly selected branches located between 1/2 and 2/3 of the total height from the ground, and crown diameter (D) was measured at the widest part of the crown (cw). Crown form was evaluated by comparing the ratio (r) of the crown diameter (D) to length (h) of the lower crown (the portion of the crown below cw) and the ratio (R) of crown diameter (D) to the length (H) of the upper crown length (the portion of the crown above cw) (*Fig. 1*).

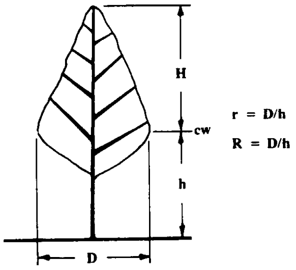


Figure 1. — Crown form ratios.

3. Cold hardiness

The studies of cold hardiness consisted of two parts: an evaluation of outdoor winter damage and an evaluation of cold acclimation by freezing tests under laboratory conditions. Outdoor winter damage was subjectively scored as the proportion of dead foliage on each tree (*Table 1*) in June 1984 and again in April 1985. Rust brown leaves and brittle twigs indicated that most of the 174 trees had been damaged during the winter of 1983—84. The pattern of development of cold hardiness was studied in laboratory freezing tests conducted on eight sampling dates from September 1984 to January 1985 (*Table 2*). Test procedures followed Rehfeldt (1979), with test temperatures based on the results of preliminary tests and local weather patterns. Branches were scored as damaged or non-damaged as indicated by browning of the normally green foliage and/or woody tissue. Tolerance of populations to freezing was assessed by regression analyses using a a logistical model:

$$Y_{ij} = 1 / (1 + A)$$

$$A = \exp (B_0 + B_1X_i + B_2X_j + B_3X_iX_j), \quad \text{or}$$

$$\ln (1/Y_{ij} - 1) = \exp (B_0 + B_1X_i + B_2X_j + B_3X_iX_j),$$

where Y_{ij} is the proportion of the population injured at temperature i and time j, X_i is the main effect of temperature, X_j is the main effect of time (defined as the number of days after the first day of fall (September 21)), and X_iX_j is the effect due to the interaction of temperature and time. An R-statistic was also computed for each model (SAS, 1983).

Table 1. — Outdoor winter damage evaluation scale.

LEVELS	TYPE	% DEAD FOLIAGE
1	most serious	>90%
2	serious	70-90%
3	moderate	40-70%
4	light damage	10-40%
5	insignificant damage	<10%

Table 2. — 1984 to 1985 test dates and temperatures used in laboratory studies of the development of cold hardiness in 5 giant sequoia populations planted in Moscow, Idaho.

TEST DATE	DAYS AFTER SEPTEMBER 21	TEMPERATURE °C			
September 20	-3	-12°	-14°	-16°	-18°
September 27	4	-5°	-8°	-11°	-14°
October 23	30	-12°	-14°	-16°	-18°
October 25	32	-15°	-17°	-19°	-21°
November 15	53	-25°	-27°	-29°	-31°
November 30	68	-25°	-27°	-29°	-31°
December 6	74	-28°	-31°	-33°	-35°
January 31	130	-29°	-31°	-33°	-35°

In addition to the population tests, thirty individual trees were tested on January 8, February 19, and March 18, 1985 for freezing damage in the laboratory. Fifteen of the trees were selected from the less-seriously winter-damaged trees and the others from more-seriously winter-damaged ones. Procedures were the same as those used in the population tests. Correlation analysis for these trees was based on average damage at −28° C, which was the temperature at which the population tests showed the greatest difference in patterns of damage frequency over time.

Results

1. Growth, phenology and morphology

The differences between populations in the average dates on which growth began and ceased were small and not significant (*Tables 3* and *4*). In 1984, the giant sequoia trees grew rapidly during July and early August. Growth slowed toward the end of August, and stopped by September 7 in the Mountain Home population and September 14 in the Cedar Flat population. The average dates on which 5th year elongation began in these population samples spanned one week and ranged from May 12 to May 19.

Although the differences in phenology among populations were not significant, a strong block effect was found for the time of growth cessation ($P = 0.0001$) (*Table 4*). This block effect is likely to be associated with differences in soil moisture levels.

After the 4th growing season, variation was significant among populations in total height, diameter, and 4th year elongation (*Tables 3* and *4*). Height and 4th year elongation showed strong block effects, and a significant block × population interaction was found for diameter growth (*Table 4*). Total height varied considerably within populations, and by the end of the 4th growing season, four individual trees were taller than 200 cm.

We found significant differences among populations in average branch angle, crown diameter, and the ratio of crown diameter to lower crown length. Block effects were small and statistically not significant for these traits (*Table 4*). Crown form varied considerably among populations and among individuals within populations. The general crown form of these populations could be described as (a) a wide-cone, as in the Mountain Home population, (b) an up-side-down wide cone, as in the Garfield and Whitaker Forest populations, and (c) a narrow cone such

Table 3. — Mean value ($\bar{x}$) and standard deviation (SD) of the characteristics assessed for 5 populations of giant sequoia trees planted in Moscow, Idaho.

TRAITS	MH* (n=25) $\bar{x}$ (SD)	G (n=26) $\bar{x}$ (SD)	CF (n=24) $\bar{x}$ (SD)	GF (n=35) $\bar{x}$ (SD)	W (n=64) $\bar{x}$ (SD)
Growth Cessation (days after June 21, 1984)	77.20 (±11.43)	82.15 (±7.07)	84.79 (±9.04)	80.19 (±7.77)	80.38 (±9.76)
Beginning of Elongation (days after March 20, 1985)	57.08 (±7.34)	53.46 (±8.72)	56.55 (±6.72)	58.83 (±5.95)	55.05 (±7.58)
4th-year Elongation (cm)	31.08 (±9.44)	37.98 (±11.24)	33.36 (±9.83)	34.98 (±7.07)	36.27 (±9.81)
Total Height (cm)	129.34 (±29.36)	152.73 (±30.50)	131.23 (±28.71)	140.13 (±27.46)	147.76 (±30.62)
Diameter (cm)	4.21 (±1.29)	4.66 (±1.09)	3.98 (±1.26)	3.93 (±0.93)	4.55 (±1.06)
Branch Angle (degrees)	56.88 (±15.30)	56.55 (±7.33)	53.09 (±6.16)	51.88 (±6.56)	60.00 (±7.42)
Crown Diameter (cm)	69.25 (±20.83)	79.54 (±23.29)	65.00 (±19.72)	65.44 (±16.22)	79.75 (±22.13)
Crown form r=D/h	1.03 (±0.28)	1.11 (±0.33)	0.95 (±0.28)	0.94 (±0.25)	1.16 (±0.50)
Crown form R=D/H	1.17 (±0.37)	1.08 (±0.40)	1.11 (±0.37)	1.01 (±0.35)	1.13 (±0.43)
Winter Damage 1984 (%)	78.80 (±17.69)	68.86 (±24.59)	81.25 (±18.61)	81.67 (±13.63)	73.65 (±18.21)
Winter Damage 1985 (%)	47.00 (±31.59)	43.12 (±31.03)	56.67 (±31.44)	48.19 (±30.76)	57.24 (±31.36)

*) MH = Mountain Home
G = Garfield
CF = Cedar Flat
GF = Giant Forest
W = Whitaker Forest

Table 4. — Mean squares (MS) and probabilities (in parentheses) of analysis of variance of traits associated with growth, phenology, crown form, and cold-hardiness of samples from 5 populations of giant sequoia grown in Moscow, Idaho.

TRAITS	BLOCKS	POPULATIONS	BLOCK X POPULATION	ERROR
Growth Cessation (days after 6/21/84)	687.95**** (0.0001)	119.57 (0.1821)	71.93 (0.4981)	75.63
Beginning of Elongation (days after 3/20/85)	76.28 (0.2490)	126.82 (0.0614)	31.84 (0.8577)	55.13
4th-year Elongation (cm)	799.11**** (0.0001)	141.46 * (0.044)	88.63 (0.3331)	77.84
Total Height (cm)	3832.86 ** (0.0030)	2652.01 * (0.0112)	1193.95 (0.1218)	796.49
Diameter (cm)	1.89 (0.1631)	3.80 ** (0.0097)	2.53 ** (0.0100)	1.10
Branch Angle (degrees)	59.54 (0.4811)	362.49*** (0.0008)	102.83 (0.1578)	71.53
Crown Diameter (cm)	340.68 (0.4968)	1937.31 ** (0.0017)	501.30 (0.3011)	424.23
Crown form r=D/h	0.2664 (0.1357)	0.4479* (0.0164)	0.0994 (0.7523)	0.1426
Crown form R=D/H	0.2629 (0.1707)	0.121 (0.5413)	0.0804 (0.9022)	0.1559
Winter Damage 1984 (%)	1184.16 * (0.0141)	977.08 * (0.0201)	319.13 (0.4682)	324.68
Winter Damage 1985 (%)	5711.77*** (0.0005)	1608.25 (0.1356)	631.93 (0.7502)	903.37

* $P \leqq 0.05$
** $P \leqq 0.01$
*** $P \leqq 0.001$
**** $P \leqq 0.0001$

as in the Cedar Flat and Giant Forest populations (see *Fig. 2* for schematic drawings of a, b, c).

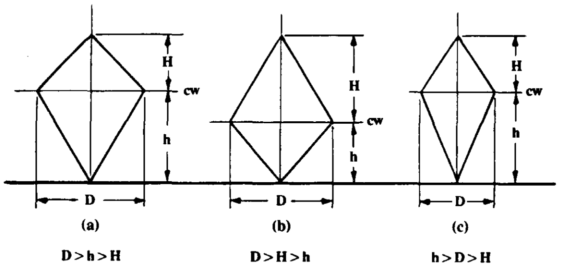


Figure 2. — Crown forms of giant sequoia trees planted in Moscow, Idaho.

Table 5. — Variance component estimation for the characteristics assessed in 5 giant sequoia populations planted in Moscow, Idaho (expressed as percent of total variation)*).

TRAITS	POPULATIONS		BLOCK X POPULATION		ERROR
	s^2	%	s^2	%	
Total Height	43.63	4.91	49.22	5.53	796.49
4th-year Elongation	1.59	1.97	1.34	1.67	77.84
Diameter	0.04	3.03	0.18	13.64	1.10
Growth Cessation	1.46	1.91	-0.46	-0.06	75.63
Growth Beginning	3.04	5.51	-2.98	-5.40	55.13
Branch Angle	9.62	11.19	4.81	5.60	71.53
Crown Diameter	44.94	9.38	9.88	2.06	424.23
Winter Damage (1984)	20.05	5.83	-0.71	-0.21	324.86
Winter Damage (1985)	30.28	3.36	-33.62	-3.74	903.37

*) Block as fixed-effect (not included in error)

Variance component analyses (*Table 5*) indicated that population accounted for only about 2% of the total variance in 4th year elongation and date of growth cessation, and about 3% to 6% in total height, diameter, and the beginning date of elongation. The latter group are consistent with the findings of MAHALOVICH (1985). Block × population interaction accounted for 13.6% of the total variance in diameter growth. Negative variance components were found for the interaction in the phenological traits. The relatively low variance component estimates for populations in growth and phenological traits likely reflects large variation among the individuals within populations.

In contrast, for branch angle and crown diameter, variance components associated with populations were higher, accounting for approximately 9% and 11% of the total variance. That is, branch angle and crown diameter appear to be under stronger genetic control than growth and phenological traits for this species. These results are in contrast to those of MAHALOVICH (1985) who found that only

Table 6. — Parameter estimates of regression models[1] by FUNCAT and models' reliability (R^2).

SOURCE[2]	MH	G	CF	GF	W
Intercept	-0.942	-2.928***	-2.247**	-2.292***	-1.757***
Time	0.070***	0.090**	0.145***	0.063***	0.085***
Temperature	0.062	0.036	0.110*	0.011	0.026
Time x Temp.	0.001**	0.002**	0.002**	0.001**	0.001***
R^2	0.47	0.46	0.46	0.47	0.48

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$

[1] See equations, p. 7

[2] MH = Mountain Home
G = Garfield
CF = Cedar Flat
GF = Giant Forest
W = Whitaker Forest

Table 7. — Pairwise comparisons of parameters of regression models[1])

POP[2]	GARFIELD		CEDAR FLAT		GIANT FOREST		WHITAKERS	
	W	PROB	W	PROB	W	PROB	W	PROB
MH	4.72	0.32	9.02	0.06	4.51	0.34	1.19	0.88
G			8.25	0.001***	1.71	0.78	2.71	0.60
CF					9.65	0.05*	8.44	0.08
GF							3.22	0.52

* $P < 0.05$

*** $P < 0.001$

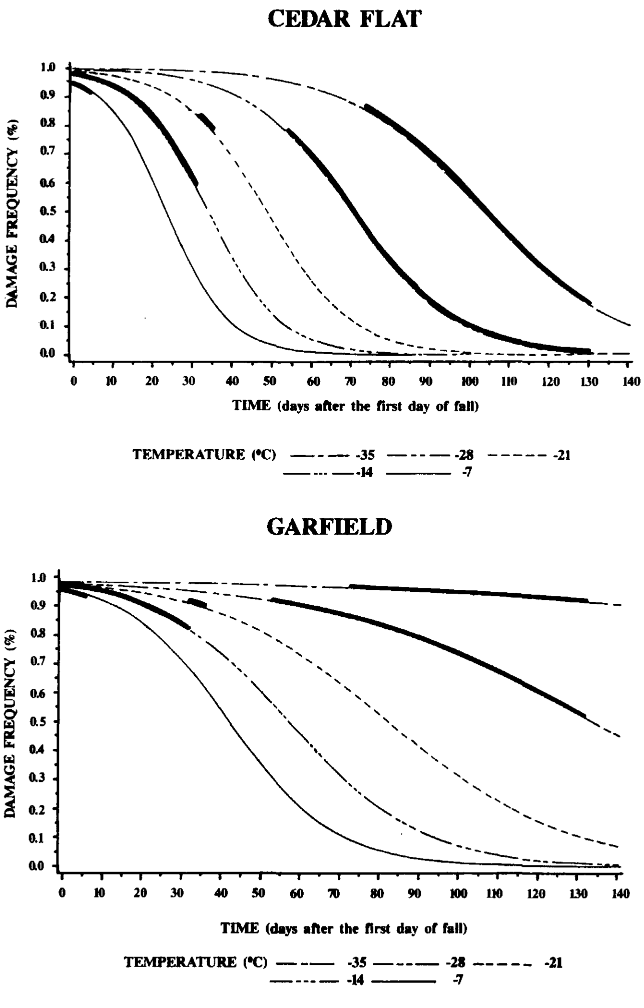
[1]) W follows a chi-square distribution. For description of methods and distribution of W see DENNIS *et al.* 1986.

[2]) MH = Mountain Home
CF = Cedar Flat
G = Garfield
GF = Giant Forest

2% or less of the variance in crown radius was associated with population differences.

2. Cold Hardiness

a) Out-door winter damage: Average winter damage for all trees was 76% after the winter of 1984, and 51% after the winter of 1985. Differences were significant among populations in winter damage in 1984, but not in 1985. Significant differences among blocks were also found for winter damage, with the trees in block 2 having the most winter damage in both years (*Table 4*).



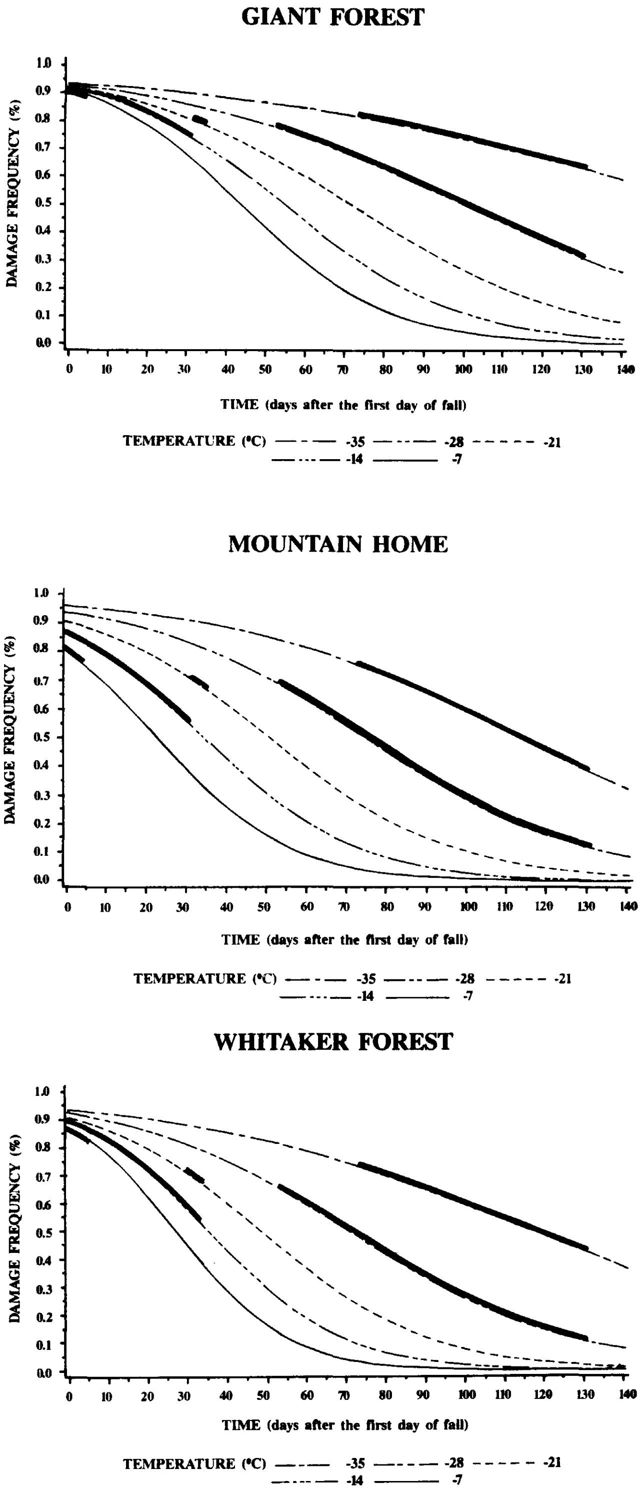


Figure 3. — Frequency of cold damage predicted by simulations using the logistic model for five giant sequoia populations planted in Moscow, Idaho. Actual data collected on dates and temperatures shown in *Table 2.* Solid lines indicate time period over which data were collected for temperatures shown in simulations (± 1° C).

b) Evaluation of cold acclimation: Regression models for the progression of freezing tolerance were highly significant ($P = 0.0001$) for all the populations. The time parameter was significant in every model whereas the temperature parameter was significant for only one. This indicates that, in explaining cold acclimation among populations, the environmental factors associated with the time of year were relatively more important than the specific temperatures used in developing the models. R^2 was moderate, ranging from 0.46 to 0.48 (*Table 6*), indicating substantial variation between observed damage frequencies and predicted values.

Freezing damage frequency decreased with time for all populations, but the rates of decrease differed (*Fig. 3*). The Cedar Flat population displays a somewhat different pattern than the others, and pairwise comparisons of the coefficients (W) of the models (DENNIS *et al.*, 1986) were significant or near significant ($0.001 \leq P \leq 0.08$) between Cedar Flat and each of the other four populations (*Table 7*).

Regression analysis showed too that at time zero, September 23, when most of the trees had just ceased growth, cold hardiness had not yet developed. The response curves were relatively flat with all the populations having a greater than 70% probabiility of being damaged at 0° C. However, by October 12 (time = 19 days), the physiological mechanisms of cold hardiness had apparently been triggered in some populations, and damage at 0° C ranged from 35% to 75%. By 120 days after the first day of fall (January 21), the average predicted damage frequency was less than 20% at −28° C for three of the populations. The predicted damage frequency in the Giant Forest and Garfield populations (the two least cold hardy), were approximately 40% and 60% at the same temperature.

Table 8. — Correlations and probabilities for 10 traits and elevation of origin of giant sequoia trees planted in Moscow, Idaho 1).

	EL	DM	GC	GB	AB[2]	CD[2]	W4	W5	FT[3]	ELEVATION
Total Height (TH)	0.68**** (0.0001)	0.85**** (0.0001)	0.33**** (0.0001)	-0.25*** (0.0008)	0.31*** (0.0002)	0.58**** (0.0001)	-0.49**** (0.0001)	-0.38**** (0.0001)	-0.42* (0.0202)	-0.03 (0.7402)
4th-year Elongation (EL)		0.48**** (0.0001)	0.51**** (0.0001)	-0.32**** (0.0001)	0.18* (0.0295)	0.30**** (0.0001)	-0.49**** (0.0001)	-0.41**** (0.0001)	-0.50** (0.0049)	-0.04 (0.6226)
Diameter (DM)			0.21** (0.0044)	-0.19** (0.0111)	0.34**** (0.0001)	0.72**** (0.0001)	-0.60**** (0.0001)	-0.34**** (0.0001)	-0.50** (0.0045)	0.06 (0.4262)
Growth Cessation (GC)				-0.29**** (0.0001)	0.04 (0.6345)	0.17* (0.0258)	-0.23** (0.0020)	-0.22** (0.0043)	-0.28 (0.1363)	-0.07 (0.3825)
Beginning of Elongation (GB)					-0.10 (0.2504)	-0.13 (0.1014)	0.19* (0.0104)	0.09 (0.2497)	0.39* (0.0338)	0.07 (0.2046)
Branch Angle (AB)						0.46**** (0.0001)	-0.30*** (0.0002)	0.06 (0.5148)	#	-0.00 (0.9863)
Crown Diameter (CD)							-0.68**** (0.0001)	-0.15 (0.056)	-0.66**** (0.0001)	0.02 (0.760)
Winter Damage 1984 (W4)								0.34**** (0.0001)	0.76**** (0.0001)	-0.08 (0.2917)
Winter Damage 1985 (W5)									0.39* (0.0308)	-0.14 (0.0625)
Freezing Damage (FT)										0.00 (0.9845)

1) Correlations based on 174 individuals, except where indicated.

2) Based on 141 individuals.

3) Based on average freezing damage to 30 individual trees tested on 3 days at −28° C.

Not calculated because of missing data.

3. Correlatiions among the traits

Significant phenotypic correlations were found among most of the traits assessed (*Table 8*). Growth traits (including total height, 4th year elongation, and bole diameter) were positively correlated with each other, and with growth cessation and morphological traits, and were negatively correlated with the date on which elongation began, winter damage, and freezing injury. Both crown diameter and growth cessation were negatively correlated with winter damage. Positive correlations were also found for winter damage in the field and freezing injury in the laboratory on the 30 individual trees evaluated in the laboratory during the two study years.

Discussion

Results of this study demonstrate modest to substantial genetic variation among the five population samples of giant sequoia in most of the traits assessed, with the Garfield population ranking highest in height and diameter growth. In general, the trees that had the least winter damage were taller than the average, with wider crown diameters and boles, larger branch angles and longer growth periods. We did not investigate the physiological relationships among the variables in this study.

Block environment had a large effect on growth, cold hardiness, and the date on which growth ceased. We suspect that soil moisture played a significant role in the severity of winter damage and rate of growth, since the trees in blocks 3 and 4, which were adjacent to a frequently watered garden, were generally taller and had longer growth periods and less winter damage than those in blocks 1 and 2.

The average dates when giant sequoia began and ceased growth were both approximately one month later than those reported for local species. For example, grand fir in northern Idaho generally starts growth by May 15, and stops growth by August 3 (Schmidt and Lotan, 1980) whereas our samples of giant sequoia began growth around June 15, and stopped growth by early to mid-September. We suspect, therefore, that cold temperatures in the early fall are likely to cause more injury to giant sequoia than to local species, but cold temperatures in the late spring are not likely to be a problem.

Weather records[1]) indicate that in the two years of this study, annual temperatures averaged −1.9° F and −3.9° F below normal in 1984 and 1985, respectively, and monthly minimum temperatures were lower in the winter months (January to March) of 1985 than they were in the winter months of 1984. Thus, the higher proportion of damage in 1984 cannot be explained by colder winter temperatures compared to 1985. However, minimum temperatures substantially below freezing (23° F) occurred nearly three weeks earlier in the fall of 1983 than in the fall of 1984 (September 28 and October 17, respectively). That is, cold temperatures in the fall of 1983 occurred when the giant sequoia trees had probably just stopped growing, and were not likely to be dormant. We suspect that this difference in the timing of cold temperatures explains the low correlations and the difference in amount of damage in the two years of the study. However, it is also possible that physiological differences associated with size and/or age of the trees may have contributed to the differences in observed damage between the two years.

We found no geographic pattern to the observed variation, but our sample area and elevational range were both limited. In contrast, Guinon *et al.* (1982), who tested a broader range of samples (22 populations), found a positive correlation between frost resistance and elevation ($r = 0.40$, $P = 0.036$) and a weak negative one between 2-year height and elevation ($r = -0.16$, $P = 0.059$). Mahalovich (1985), using rooted cuttings from 23 population samples, found weak correlations between first year height and latitude and longitude, and weak positive ones between third year height and height growth and elevation of population origin, but considered the latter unreliable and "likely due to random chance". Given the differences in sample ranges, test materials and test locations, such differences in results are not surprising.

We found that cold hardiness developed rapidly in the early fall and slowed during the late fall and early winter for all populations. We also found significant differences among populations in predicted patterns of cold acclimation. However, the R^2 values for the models ranged from 0.46—0.48 suggesting that experimental error may have introduced extraneous variation.

Although we found significant differences among populations for many of the traits evaluated, perhaps a more important observation was the wide variation among individuals within populations. This variation presents the possibility of selecting individual genotypes adapted to specific new environments. In this study, six trees (2 each from the Whitaker and Garfield populations, and one each from the Cedar Flat and Mountain Home populations) maintained green foliage through the winter of 1984 to 1985 when the foliage of all the other trees became brown or yellow brown. These six trees, which also grew rapidly in this environment, may have the potential for use as ornamentals in northern Idaho.

Conclusions and Recommendations

Significant genetic variation in growth, crown form, cold hardiness and patterns of cold acclimation was found among five populations of giant sequoia grown in northern Idaho. Differences in phenological traits were not significant. Significantly positive correlations were found among growth traits, among morphological traits, and among measures of cold damage. Significant negative correlations were found between growth traits and measures of cold damage. No geographic patterns were detected for the traits measured. Although none of the five population samples observed looked promising as origins of random seedlings for ornamental planting in northern Idaho, six individual genotypes were identified that may be suitable, and further clonal propagation, testing and broader planting are planned.

Our study shows that selection for cold hardiness and adaptation should be conducted at the individual tree level for the populations tested, since none of the populations showed vastly superior growth or cold hardiness compared with others. However, many populations remain untested in this environment and may ultimately yield genotypes superior to those identified in this study.

Successful use of any species as an ornamental will depend not only on appropriate choice of specific individuals, but also on an appropriate match of those individuals to planting sites. A further study testing the per-

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[1]) Temperature information from "Climatological Data, Idaho". Volumes 86—87, 1983—1985. National Oceanic and Atmospheric Administration.

formance of selected genotypes over a broad spectrum of sites needs to be conducted.

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Buchbesprechungen

Plant Molecular Biology Manual. Edited by S. B. Gelvin and R. A. Schilperoort. Kluwer Academic Publishers, Dordrecht/Boston/London, 1988. ISBN 90-247-3633-1. Price: Dfl 110.00.

Rapid progress has been made in the area of plant molecular biology during the past decade. New technologies have been developed for the transfer of genes in plants and for *in vitro* regeneration of recalcitrant plant species. As a result the scientific marketplace has been flooded with rapidly changing techniques, often making it difficult for a newcomer to select the appropriate technique to resolve a molecular biology problem. Plant Molecular Biology Manual contains techniques that have become routine and can be employed in the laboratory by advanced college students and research scientists interested in plant molecular biology. The manual is divided into three sections. Section A deals with Introduction of Genes into plants and contains the following chapters: 1) Direct DNA transfer to protoplasts with and without electroporation (Michael *et al.*); 2) Use of cointrgrating Ti plasmid vectors (Rogers *et al.*); 3)Binary vectors (An *et al.*); 4) *Agrobacterium* molecular genetics (Hooykaas); 5) Leaf disc transformation (Horsch *et al.*); 3) Extraction of DNA from plant tissues (Rogers and Bendich); 7) Procedures for constructing ds-cDNA clone banks (Slightom and Quemada); 8) Procedures for constructing genomic clone banks (Slightom and Drong); and 9) Selectable and screenable markers (Reynaerts *et al.*). Section B deals with Expression of Genes in Plants and contains the following chapters: 1) Use of reporter genes to study gene expression in plant cells (Herrera-Estrella *et al.*); 2) Assays for studying chromatin structure (Paul and Ferl); 3) Assays for studying DNA methylation (Razin); 4) Analysis of gene expression in transgenic plants (Nagy *et al.*); 5) Subcellular targeting of proteins *in vivo* and *in vitro* (Schreier *et al.*); 6) Isolation of total and polysomal RNA from plant tissues (de Vries et al.); and 7) Translation in *Xenopus* oocytes of mRNAs transcribed *in vitro* (Kawata *et al.*). Section C deals with Fate of Introduced Genes and contains the following two chapters: 1) Stability of introduced genes and stability in expression (Dunsmuir *et al.*); and 2) Restriction fragment length polymorphism (Bernatzky).

Each chapter is organized to give the theoretical background, the procedures, and the relevant references. This is a useful and timely manual on plant molecular biology. M. R. Ahuja

Farbatlas Waldschäden. Diagnose von Baumkrankheiten. Von Günter Hartmann, Franz Nienhaus und Heinz Butin. Verlag Eugen Ulmer, Stuttgart. 1988. 256 Seiten, 418 Farbfotos. Kartonierter Einband, DM 32,— (ISBN 3-8001-3306-7).

Die exakte Diagnose von Baumkrankheiten erfordert umfassende Kenntnisse der auftretenden Schadbilder und ihrer möglichen Ursachen. Mit zunehmenden Schäden durch anthropogene Luftschadstoffe wird die Differenzierung zwischen den hierdurch hervorgerufenen Symptomen und den seit langem bekannten Schadbildern sehr erschwert. Hier fehlte bisher ein Werk, das die wichtigsten Schadsymptome unserer Baumarten vergleichend anhand von Farbbildern darstellte. Diese Lücke ist nun mit dem „Farbatlas Waldschäden“ geschlossen worden. Autoren und Verlag sind zu dieser ausgezeichneten Neuerscheinung zu beglückwünschen. Die Qualität der Abbildungen und der kurze, präzise Text zu den Erkennungsmerkmalen, den Verwechslungsmöglichkeiten und den Umständen des Auftretens lassen keine Wünsche offen. Die Farbbilder zeigen typische Symptome, wie sie im Wald mit bloßem Auge oder mit der Lupe zu erkennen sind. Kurze Bestimmungsschlüssel und Querverweise bei den Abbildungen führen bei den 16 behandelten Waldbaumgattungen bzw. -arten zu insgesamt mehr als 200 wichtigen, häufigen oder auffälligen Krankheitserscheinungen. Dieses empfehlenswerte und wichtige Buch wird in Zukunft die Ansprache von Waldschäden ganz wesentlich erleichtern. Darüber hinaus ermöglicht das handliche Taschenformat die Mitnahme in den Wald. Das Buch ist ein „Muß“ für alle am Wald Interessierten und für alle, die sich wegen der Schäden in unseren Wäldern Sorgen machen. B. R. Stephan

Farbatlas der Basidiomyceten. Colour Atlas of Basidiomycetes. Von Prof. Dr. Dr. Meinhard Moser, Innsbruck, und Dr. Walter Jülich, Leiden, unter Mitarbeit von Cuno Furrer-Ziogas, Basel. Verlag G. Fischer, Stuttgart, New York. Lieferung 5. 1988. 20 S. und 162 farb. Abb. auf 76 Tafeln. DM 98,— (ISBN 3-437-30570-0). Lieferung 6. 1988. 18 S. und 163 farb. Abb. auf 78 Tafeln. DM 98,— (ISBN 3-437-30595-6).

Der 1985 begonnene Farbatlas der Basidiomyceten wurde 1988 mit zwei weiteren Lieferungen fortgesetzt. Damit sind inzwischen über 700 Arten und Unterarten aus 120 Pilzgattungen farbig abgebildet. Ausführliche Gattungsdiagnosen in deutsch, englisch, französisch und italienisch wurden bereits von 65 Gattungen verfaßt. Weitere werden in den kommenden Lieferungen enthalten sein. Jede Pilzart ist auf einer halben oder ganzen Seite mit ausgezeichneten Farbfotografien von verschiedenen Fruchtkörpern oder Details abgebildet. Der Ringbuch-Charakter des Farbatlas ermöglicht ein leichtes Einordnen der Tafeln neuer Lieferungen. Bereits jetzt ist das Werk eine hervorragende und unentbehrliche Hilfe bei der Bestimmung der Basidiomyceten nach den von denselben Autoren verfaßten und im gleichen Verlag erschienenen Bestimmungsbüchern der „Kleinen Kryptogamenflora“. Trotz des hohen Preises (die bisher erschienenen 6 Lieferungen kosten komplett 602 DM) ist der Farbatlas jedem ernsthaften Mykologen uneingeschränkt zu empfehlen. B. R. Stephan

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