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TREE-RING AND CLIMATE RELATIONSHIPS FOR *ABIES ALBA* IN THE INTERNAL ALPS

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ABSTRACT

The relationships between the tree-rings of the white fir (*Abies alba* Mill.) and climate in the French internal Alps are indicated by correlation functions. This fir shows an accurate response to climate as well as long term persistence for at least six years (MS=0.18, R_1=0.65, and R_6=0.27). Its growth is strongly influenced by the previous year's climate, especially by prior August rainfall, which enhances ring size, or by high temperatures, which show the opposite effect. The most critical period extends from prior July to prior September. This species responds positively to warm temperature from current January to April, followed by rainfall in May and June, which leads to a longer growth period. A favorable water balance seems to be decisive. *Abies alba* can be affected by frost and seems to prefer a low thermal amplitude as demonstrated by the analysis of the extreme temperature data. Moreover, even a few days of excessive heat can reduce its growth.

Die Beziehungen zwischen den Jahresringen der Weiβtanne (*Abies alba* Mill.) und das Klima in den zentralen französischen Alpen deuten Korrelationen an. Diese Tanne zeigt sowohl eine direkte Reaktion auf das Klima als auch langfristige Auswirkungen über mindestens sechs Jahre (MS=0.18, R_1=0.65, und R_6=0.27). Ihr Wachstum ist stark durch das Klima des vorherigen Jahres beeinfluβt, vor allem durch Regenfälle vor dem ende des monats Juli, die zu einer erhöhten Ringgröβe führt, oder durch hohe Temperaturen, die das Gegenteil bewirken. Die kritischste Periode erstreckt sich von ende Juni bis ende August. Diese Art reagiert positiv auf warme Temperaturen von Januar bis April, gefolgt von Regenfall im Mai und Juni, was zur einer verlängerten Wachstumsperiode führt. Ein günstiges Wasserverhältnis scheint ausschlaggebend zu sein. *Abies alba* kann von Frost beeinfluβt werden und scheint eine niedrigere thermische Amplitude zu bevorzugen, wie die Analyse der extremen Temperaturdaten veranschaulicht. Auβerdem kann ihr Wachstum schon durch wenige Tage übermäβiger Wärme reduziert werden.

On analyse les relations entre les cernes du Sapin pectiné (*Abies alba* Mill.) et le climat au moyen des fonctions de corrélation. Le Sapin montre une bonne réponse au climat et une inertie à long terme sur au moins 6 ans (MS=0.18, R_1=0.65, and R_6=0.27). Sa croissance est fortement influencée par le climat de l'année précédente, en particulier par les précipitations en Août (n-1) qui augmentent les largeurs de cernes, ou par de fortes températures qui montrent simultanément un effet opposé. La période la plus critique va de Juillet (n-1) à Septembre (n-1). Cette essence apprécie des températures chaudes de Janvier (n) à Avril (n), suivies de pluies en Mai (n) et Juin (n), ce qui conduit à une plus longue période de végétation. Un bilan hydrique favorable semble être essentiel au Sapin. Il peut être affecté par le gel et semble préférer une amplitude thermique réduite, comme le montre l'analyse des données de températures extrêmes. De plus, même quelques jours trop chauds peuvent réduire sa croissance.

INTRODUCTION

White fir (*Abies alba* Mill.) is a widely distributed coniferous species in Europe (Rol 1937). Consequently, the forest diseases that have been reported in fir forests raise many problems for foresters and tree physiologists (Cramer and Cramer-Middendorf 1984). Climatic events are known to be involved in this phenomenon (Fourchy 1951). For instance, dry years usually reduce tree growth and, according to several authors, may trigger disease (Becker 1989).

For that reason, it seems important to precisely analyze the influence of climate on white fir growth. Several methods, either ecophysiological (Aussenac 1973, 1975; Becker 1982; Hinckley and Ritchie 1972) or dendroclimatological (Becker 1989; Fritts 1966, 1976; La Marche 1974; Polge 1971; Tessier 1981), can be used for this purpose. Since the latter elucidate the influence of climate over long periods of time, we used dendroclimatological methods to study the ring growth and climate relationships in white fir. A particularly dry growth site was chosen to contrast the results with other studies of this species, which were achieved in milder climates such as Italy (Corona 1983), southeastern Germany (Becker and Giertz-Siebenlist 1970), and France in the Mont Ventoux (Serre Bachet 1986) and the Vosges (Becker 1989).

MATERIALS AND METHODS

Sampling

A forest called "le Bois des Bans" near Briançon (Hautes-Alpes, France), where white fir grows from 1520 meters to 1820 m elevation on north facing slopes ranging from 0° to 40°, was chosen for this study. In 31 plots (one per hectare), 310 cores were taken at breast height with a Pressler borer. The five tallest trees in each plot were sampled, with two cores per tree taken in opposite directions perpendicular to the slope. Eight cores were eliminated, and the 42,406 ring-widths of the 302 remaining cores were measured in our laboratory (Rolland 1993).

Tree-Ring Data

For each core, the average of all the ring-widths ($<C>$), the mean square (σ^2), and the coefficient of variation (CV) are calculated by the formulas:

$$<C> = \frac{1}{N} \bullet \sum_{i=1}^{i=N} (C_i) \quad = \text{Average of all the rings (0.01mm)}$$

$$\sigma^2 = \frac{1}{N-1} \bullet \sum_{i=1}^{i=N} \left(C_i - <C>\right)^2 = \text{Mean square (0.01mm)}$$

$$CV = \frac{\sqrt{\sigma^2}}{<C>} \bullet 100 \quad = \text{Coefficient of variation (percent)}$$

where:
C_i represents ring number i.
N is the age of the tree (number of rings).
Mean Sensitivity (MS) is given by:

$$MS = \frac{2}{N-1} \bullet \sum_{i=1}^{i=N} \frac{|C_{i+1} - C_i|}{C_{i+1} + C_i}$$

The autocorrelation coefficients R_k are given by:

$$R_k = \frac{1}{\sigma^2 (N-k-1)} \bullet \sum_{i=1}^{n-k} (C_i - <C>) \bullet (C_{i-k} - <C>)$$

A lag, k, ranging from 1 to 30 years is included in this study, and an average value $<R_k>^2$ is obtained with all the cores.

The growth indices for each core are obtained by using a moving average with seven terms to remove the effect of long-term trends such as the age effect or the influences of human activities. After synchronizing the individual series, a master chronology is built by averaging all the cores (Rolland 1993).

Meteorological Data

The meteorological station of Briançon, at an elevation of 1324 m, has continuously recorded daily precipitation and temperature data since 1947 and solar radiation since 1961. The average annual rainfall for the last 30 years (1961-1990) is 713 mm, and the mean annual temperature is 7.5°C.

Calculation of the Response Functions

Since the first autocorrelation coefficient is high ($<R_1>^2=0.65$), the influence of the previous year is expected to be important. Consequently, twelve months of the prior year, from January to December, are used in addition to the data of January through September during the current year of growth. Thus, 21 months are employed (Fritts 1976). The effects of five parameters are studied separately: (1) total monthly rainfall in mm per month, (2) average monthly temperature (°C), (3) solar radiation (hours per month), (4) average monthly minimum temperature (°C), and (5) average monthly maximum temperature (°C). We calculated the correlation functions instead of the response functions because they are easier to interpret (Blasing et al. 1984). Thus, the correlation coefficients between the indices of growth and the monthly climate data are calculated for each parameter.

RESULTS

Mean Sensitivity and Autocorrelation

Before analyzing the influence of climate, three important tree-ring parameters were calculated: mean sensitivity (MS), the coefficient of variation of the ring-widths (CV), and the autocorrelation coefficients (R_k). The first measure (MS) describes the variability of the high frequency component of the ring-widths due to climatic fluctuations, while the second (CV) represents low frequency variability caused either by climate or by other long term influences.

The third value (R_k) describes the influence of growth during the year n-k on growth during the year n.

The coefficient of variation ranges between 2 and 12 percent, and the repartition curve exhibits a bell shape (Figure 1). Moreover, the mean sensitivity shows a similar pattern, ranging between 0.121 and 0.258 (Figure 2). In comparison, the MS is about 0.3 in Mediterranean regions (Tessier 1982), while in Arizona it can reach 0.6 to 0.8. In Briançon, the average value is 0.179, which is enough to obtain accurate results with the correlation function method.

The autocorrelation coefficients $\langle R_k \rangle^2$ show a rapid decrease with lag k (Table 1, Figure 3). It appears that the first six R_k coefficients are high enough to completely characterize the autocorrelation because for the order k=6, $\langle R_6 \rangle^2$ equals only 0.27. This phenomenon may be due to several factors. Growth during previous years influences growth of the current year because nondeciduous coniferous species keep their needles for several years, but the efficiency of old

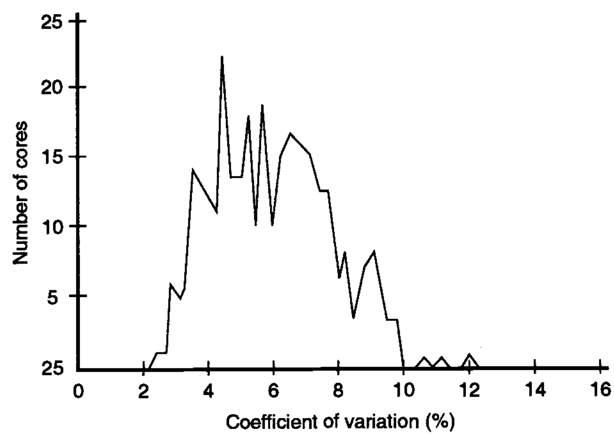

Figure 1. Distribution of coefficients of variation among the 302 *Abies alba* Mill. cores.

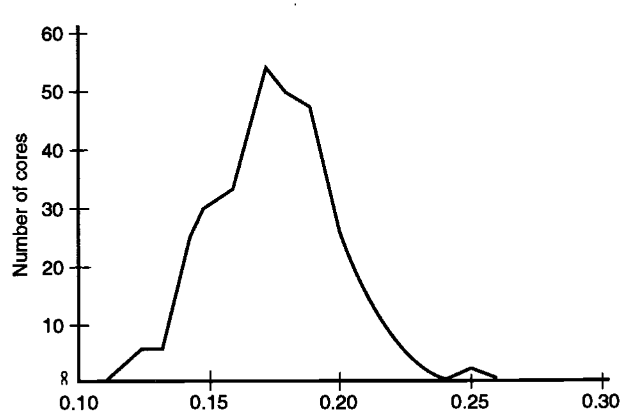

Figure 2. Mean sensitivity of 302 *Abies alba* Mill. cores.

Table 1. Autocorrelation coefficients (r_k^2) for ten lags (k).

k	1	2	3	4	5	6	7	8	9	10
R_k^2	0.65	0.56	0.46	0.38	0.33	0.27	0.23	0.20	0.17	0.14

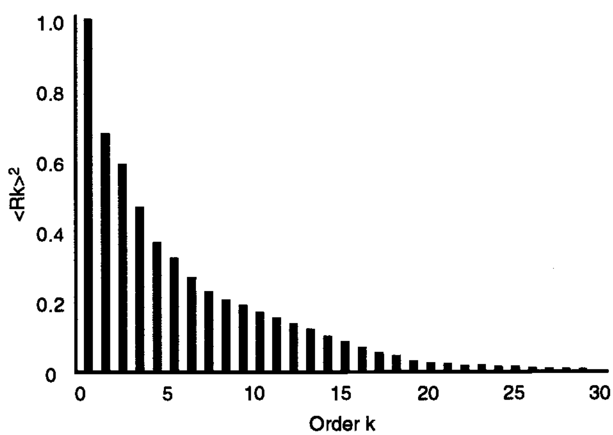

Figure 3. Autocorrelation coefficients, $<R_k>^2$, with order k ranging from 0 to 30 years (average of all the cores).

needles decreases with age. If needles are destroyed by frost or insect attacks, tree growth will be reduced the following year. For instance, young Scots pines attacked by insects recover their normal growth after only one year, whereas older trees (more than 80 years old) need about four years (Laurent-Hervouet 1986). Moreover, snow falling during year n-1 provides water reserves for year n. The buds are also initiated during the previous vegetative period. The development of the root system or the effects of forestry practices such as thinning may also be responsible for long term correlations. All these factors explain why the R_1 value ($<R_1>^2=0.65$) is so important. Consequently, the previous year must be taken into account in time series analysis.

Climatic Effects

Since the rainfall is low in the Briançonnais, this parameter is quite important. The firs react positively to precipitation during their vegetative period, since rainfall in current May and July is positively correlated with growth (Figure 4A). Similarly, rainfall during the previous year has a positive influence from prior July to prior October, particularly in prior August and September. This effect is more extended and accurate than rainfall effects during the year of growth, since rainfall provides water reserves for the following year. Because a lack of rain strongly reduces growth, firs do not tolerate water stress.

Warm springs during the vegetative period are very favorable for growth, especially current February to April and more significantly current March (Figure 4B). In the internal Alps, the winters are long and cold, especially on north facing slopes, so a warm spring may activate the cambium earlier and accelerate snow melt, which may enhance growth (Graumlich 1991).

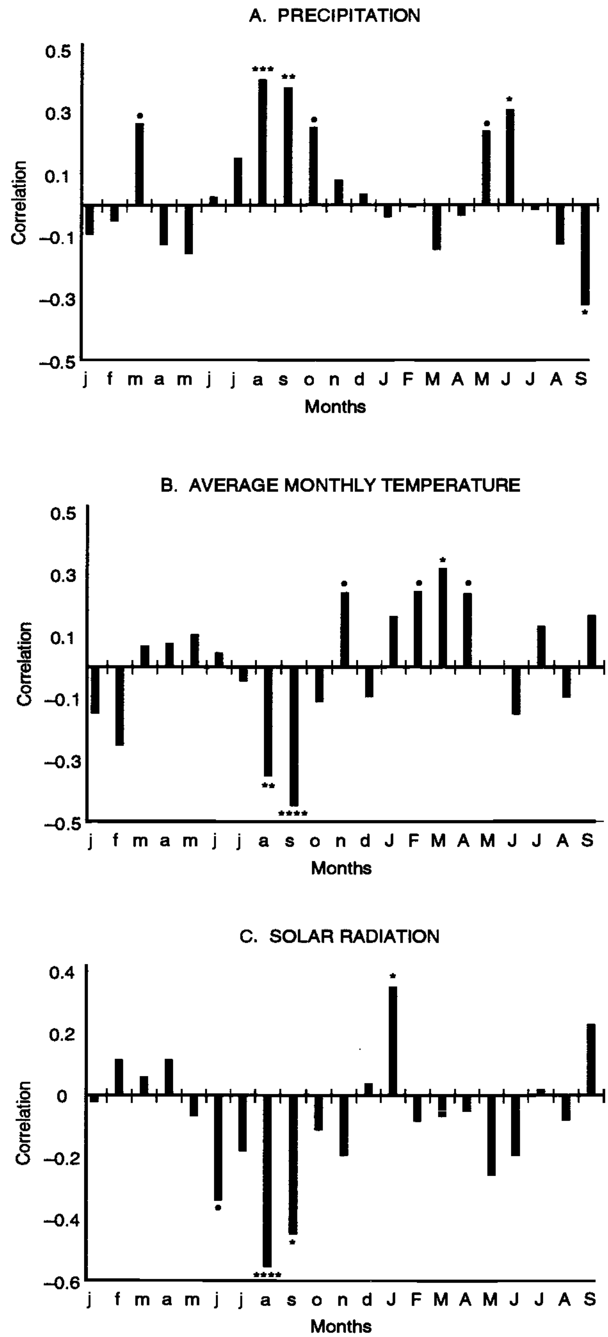

Figure 4. Correlation functions for white fir growth and (A) total monthly precipitation, (B) mean monthly temperature, and (C) monthly solar radiation during the previous and current years. Correlation coefficients that exceed significance levels 0.9, 0.95 0.975, 0.99, and 0.995 are shown respectively by •, *, **, ***, and ****.

Moreover, the activation of fir buds is sensitive to high temperatures (Aussenac 1975).

Previous-year temperature also plays an important part. Clearly, a warm prior August and September reduces growth the following year. During this period, water reserves in the soil are gradually reduced, since rainfall is not sufficient to offset the transpiration of the trees. Consequently, the firs become increasingly sensitive to the thermal stress. Since current spring frost reduces growth, white fir can be called a frost sensitive species. A warm prior November seems to be favorable, perhaps because it characterizes a mild winter.

Most of the time, high solar radiation (Figure 4C) has a negative effect on fir growth, which contrasts with other species such as larch. Though the duration of sunshine is usually brief on northern slopes, the radiation seems to be at all times sufficient for white fir photosynthesis. Being shade tolerant (Rol 1937), this species does not require a very sunny climate to grow. The influence of solar radiation is essentially the opposite of that of precipitation because high radiation usually implies both low rainfall and warm temperatures. Thus, higher radiation in current May and June reduces growth because rain is decisive during this critical period. This phenomenon is observed more accurately during May to November of the previous year, especially in prior August when the fir requires mild temperatures and sufficient rainfall simultaneously. The favorable effect of solar radiation during current January is probably indirectly due to the warming of the air (Fairbridge 1987).

Since $T_{\overline{X}} = .5\ (T_{min}+T_{max})$, this value describes the temperature influences well. The use of T_{min} and T_{max} separately, however, can provide more detailed information (Figure 5A and B). Thus, the negative influence of warm temperature in current June is clearly due to the role of the maximum values and not to the minimum. Similarly, the negative part played by warmth in prior August or September is more closely linked with maximum temperatures. Consequently, the hypothesis of an increase in transpiration is confirmed: higher temperature during the day increases the vapor pressure deficit of the air and may lead to thermal stress and stomatal closure.

In contrast, the positive effect of current July temperature is not due to the maximum temperature but to the increase of the minimum. The same phenomenon appears in prior November, which means that the nights are milder and the thermal amplitude reduced. The continental trend of the climate seems unfavorable to fir growth, which may be affected by frost. High minimum temperatures in previous May or June also are favorable, probably because the buds are inhibited by a cold period.

Both minimum and maximum temperature data help analyze correlations with mean temperature. It also would seem interesting to investigate the part played by absolute daily temperature, since a few days with frost can destroy the cambium and modify the growth even when the monthly average is normal. (Some information is lost by averaging the 31 values over a complete month.) This method requires using daily values to detect extremes. It reveals some phenomena that cannot be found with monthly averages. Thus, a few days in prior December with high maximum temperatures can greatly reduce growth the following year, perhaps because the warming activates tree respiration and the consumption of metabolical reserves that should have been used during the following spring (Figure 5C). Only a few days with high maxima in spring are efficient, because they accelerate activation of the buds. In contrast, the limiting effect of February frost described by Becker (1989) does not appear here, but a late frost during the day in current July strongly affects the firs.

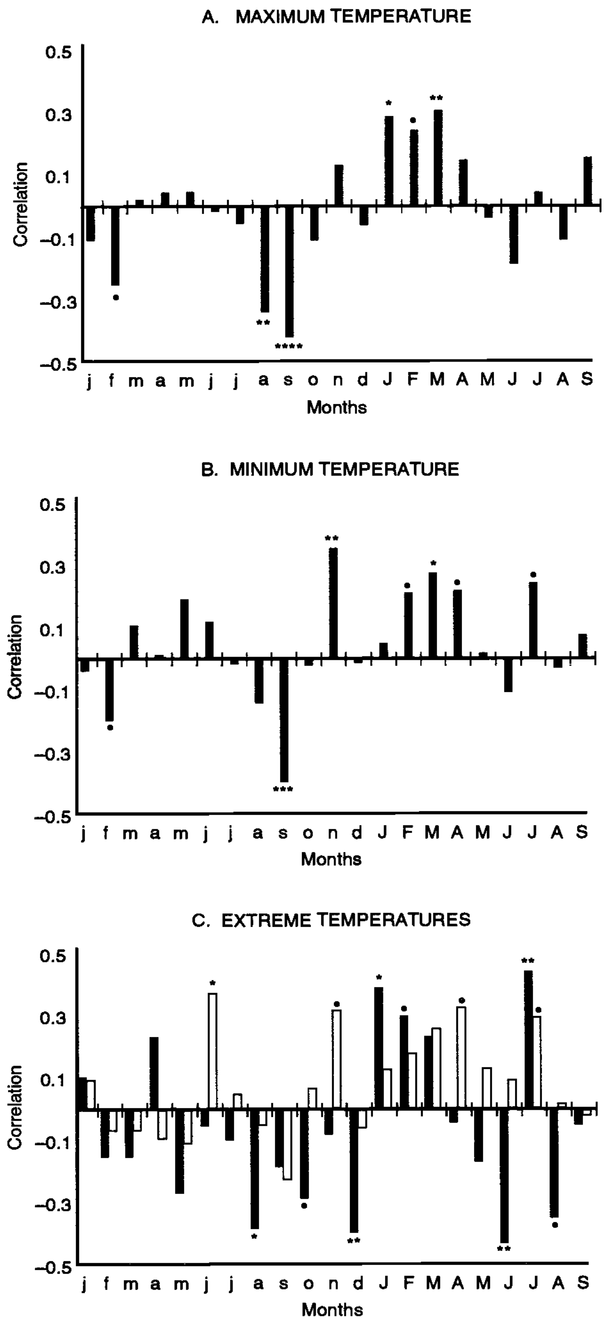

Figure 5. Correlation functions for white fir growth and (**A**) maximum temperature, (**B**) minimum temperature, and (**C**) extreme temperatures. Correlation coefficients that exceed significance levels 0.9, 0.95, 0.975, 0.99, and 0.995 are indicated repsectively by •, *, **, ***, and ****.

CONCLUSIONS

This dendroclimatic analysis carried out on white firs in severe climatic conditions of drought reveals many elements of the ecology of this species. A mean sensitivity of 0.18 indicates a response to climatic factors, and the autocorrelation coefficients demonstrate low frequency effects for about six years. The climate during the year prior to growth is important because $\langle R_1 \rangle^2=0.65$. Moreover, its influence is greater than that of the year of growth.

Many coefficients of the correlation functions are highly significant and have important ecophysiological implications. White fir is a shade tolerant species and does not require high insolation, even on north facing slopes. On the contrary, high insolation is unfavorable. The species seems to prefer a reduced temperature amplitude.

White fir strongly suffers from deficient rainfall and excessive temperatures in prior August and September. This is the most critical period for this species, since water reserves are at their lowest point at the end of the summer. Consequently, the water balance appears to be the most relevant factor in radial growth. Hot and dry days may provide a signal to the tree by inducing strong water stress that causes the fir to close its stomates to reduce transpiration. We may also assume that, during the hot period, radial growth is reduced because the tree, in order to absorb more water, develops its root system instead of producing wood for the trunk or the branches.

Because growth is strongly linked to climate, we attempted to describe the growth indices with linear multiple regression (Becker 1989). The annual climatic values of the current year explain only 30 percent of the variability in ring width. Monthly data, however, provide better results. For instance, R^2 equals 0.350 by using eight monthly values of precipitation and average temperature, and R^2 reaches 0.463 by adding maximum and minimum temperatures. This result confirms that extreme data provide more information than average values. Furthermore, solar radiation is also strongly linked to the tree rings because the R^2 value reaches 0.740 with the use of precipitation, average temperature, and radiation.

The best model includes the climatic data of both the current and previous years, which produces an R^2 of 0.894. This equation is:

$$I = 6.1947\,(T_7) + 0.0059\,(R_9) + 0.1422\,(P_6) + 0.0672\,(R_{10}) - 4.3694\,(U_9) + 2.9004\,(U_5) + 0.0532\,(P_{12}) + 0.0453\,(R_1) + 3.2289$$

where:

T_7 = current July temperature

R_9 = prior September precipitation (reserves)

P_6 = current June precipitation

R_{10} = prior October precipitation (reserves)

U_9 = prior September temperature (rapid end of summer)

U_5 = prior May temperature (warm May)

P_{12} = current December precipitation (rapid end of current summer)

R_1 = prior January precipitation (snow melt)

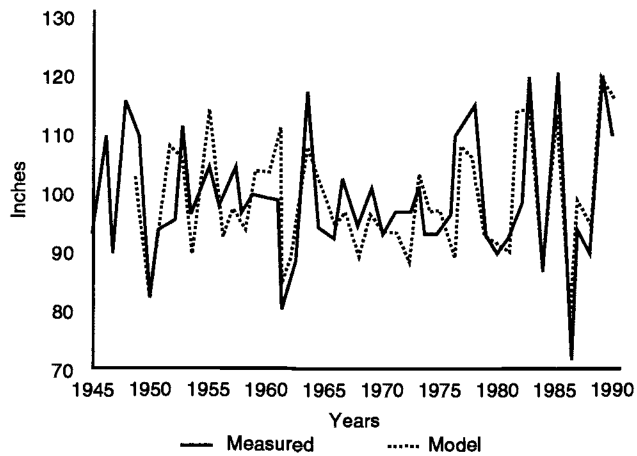

Figure 6. Time series analysis of white fir ring growth in the Alps.

Table 2. Effects of extreme climatic events on white fir radial growth.

Year	Ring Growth	Climatic Variable	Period	Difference	Cause
1985	+++	Precipitation	May -> Aug.	+29%	favorable rainy summer
1983	+++	Precipitation	May -> Aug	+38%	favorable rainy summer
		Precipitation	Apr - May	+220%	refill soil reserves
1964	+	Temperature	Jan -> May	+1.3°C	hot spring before growth
		Temperature	Jan - Feb	+3.0°C	no frost damage
1962	– –	Precipitation	May -> Aug	–59%	severe drought in summer
1986	– – –	Precipitation	May -> Aug	–39%	severe drought in summer
		Temperature	Jan -> Apr	–2.0°C	excessively cold spring
		Temperature	Feb.	–4.0°C	frost damage

As can be seen in Figure 6, the dotted line that represents the calculated values is quite similar to the measured ring widths.

The influence of extreme climatic events on the relationships revealed by the time series analysis are analyzed by subtracting the "normal" climatic data from the measured extreme values. These differences during critical periods are expressed in percentages or degrees C for the major positive or negative tree-growth values in Table 2.

Given the results of this time series analysis, it should be possible to use the ring widths for reconstructing aspects of past climate in the Hautes-Alpes (Schweingruber et al. 1991). Because a similar study was carried out on *Pinus uncinata* in the same area, combined use of the two coniferous species should provide more accurate results.

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DETERMINING THE GERMINATION DATE OF WOODY PLANTS: A PROPOSED METHOD FOR LOCATING THE ROOT/SHOOT INTERFACE

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ABSTRACT

A method for determining the germination dates of trees is based on wood anatomical characteristics and dendrochronology. This procedure requires destructive sampling of the tree for an extensive analysis of the zone between the roots and the trunk of the tree (root/shoot interface). The method is applicable to forest ecology and woody plant life history studies.

Die Methode zur Bestimmung des Keimzeitpunkts bei Bäumen basiert auf der Charakteristik der Holzanatomie und der Dendrochronologie. Das Verfahren erfordert ein destruktives Sammeln von Baumproben für eine umfassende Analyse der Zone zwischen Wurzel und Baumstamm ("root/shoot interface"). Diese Methode ist in der Waldökologie und bei geschichtlichen Studien über Holzpflanzen anwendbar.

La méthode destinée à déterminer la date de germination des arbres est basée sur des caractéristiques anatomiques du bois et sur la dendrochronologie. Cette procédure exige un échantillonnage destructif de l'arbre pour réaliser une analyse complète de la zone située entre les racines et le tronc (interface racine - pousse aérienne). La méthode est applicable en écologie forestière et pour l'étude de l'histoire de la vie des plantes ligneuses.

INTRODUCTION

The increased interest in and use of dendrochronological procedures in forest ecology and woody plant life history studies has led to a need for a procedure to accurately determine the date of tree germination. A pith date obtained at dbh (1.37 m) only represents the age of the tree at that height, not necessarily the absolute age of the tree or the year of germination (Telewski and Lynch 1991). In many cases, suppressed understory trees can grow for 100 to 150 years before attaining a height of 1.37 m (Morris 1948; Tucker et al. 1987).

Telewski and Lynch (1991) state that the germination date of a woody plant can be determined by locating the boundary between the root and the shoot (tree trunk), and determining the pith date in the trunk at this location. To apply this method in ecological studies, a working knowledge of plant morphology and anatomy is necessary to interpret the boundary between shoot and root structure. The boundary between the shoot and root (root/shoot interface) occurs in the primary structure of the embryonic tissues, between the radicle (embryonic root) and hypocotyl (embryonic shoot below the cotyledons or embryonic leaves). The primary xylem structure remains intact within the xylem tissues of a mature tree. All subsequent primary tissues are produced by apical meristems above the cotyledons (epicotyl) and at the tips of roots. The subsequent secondary growth originates from the lateral meristems or cambial tissues, resulting in the formation of growth rings and bark. It is the formation of these rings that is necessary for assigning a calendar year to the germination date using the established methods of dendrochronology (Fritts 1976; Stokes and Smiley 1968). For a review of primary and secondary growth in the stems of woody plants, see Esau (1965, 1977).

COMPARATIVE ANATOMY IN THE STEMS AND ROOTS OF VASCULAR PLANTS

In 1886, Van Tieghem and Douliot (1886) published the Stelar Theory to interpret the evolutionary sequence represented by differences in morphology of the primary vascular and associated tissues (collectively referred to as the stele) between different groups of plants. A review of the concept of the stele can be found in Esau (1965, 1977) and Foster and Gifford (1974). Very primitive vascular plants possess a relatively simple vascular system in both shoots and roots. The protostele is characterized a by a solid core of primary xylem surrounded by an outer layer of primary phloem. More advanced vascular plants developed a more complex primary vascular system in their shoots. The siphonostele contains a central column of pith and a primary tissue composed of thin, nonlignified, isodiametric cells and is considered phylogenetically more advanced than the protostele. This type of stele is characteristic of the shoots of many ferns.

Coniferous and dicotyledonous trees possess a stele within the shoot that appears, in transverse section, as a ring of more-or-less discrete vascular bundles separated by parenchyma tissue with a central core of pith. Brebner (1902) named this vascular configuration the eustele. A clearer understanding of the structure and function of the eustele, and associated phyllotaxy, must include a three-dimensional view of the primary vascular system. Fortunately, for the purpose of this paper, an in-depth analysis and comparison of stele types and function is not necessary. A detailed description of stelar structure is presented by Beck et al. (1983).

In plants with a eustele, the transition from primary growth to secondary growth is marked by the development of a vascular cambium within and between the primary vascular bundles. Development begins first between the primary xylem and phloem of the vascular bundles (fascicular cambium) and then in the spaces between the vascular bundles (intrafascicular cambium). Over a relatively short period of time, the vascular cambium forms a sheath in the shoot. Further development of this tissue results in the formation of secondary phloem (to the outside) and secondary xylem (to the inside). If phenological and developmental conditions favor growth ring development within a species of tree, this first layer of primary and subsequent secondary xylem produced during the first year of growth will represent the first tree ring. All subsequent growth rings are then produced by the vascular cambium.

As the vascular plants evolved increasingly complex primary vascular organization within the shoots, the stelar configuration of the root remained primitive. The protostele is the functional vascular architecture in the roots of conifers and dicotylenous woody plants. A three-dimensional reconstruction of the xylem in the transition zone from shoot to root, would approximate the structure of a narrow champagne glass. The solid glass wall would represent both the primary and secondary xylem while the hollow portion, which holds the liquid, represents the pith. The point where the glass constricts to form the solid 'stem of the glass' is analogous to the xylem of the shoot constricting at the base of the tree trunk, excluding the pith from the root. This position is the root/shoot interface and represents the oldest tissues of the plant. The pith date in the shoot (tree trunk), or the xylem core date in the root at this position represents the date of germination.

It should be noted that this date can not be used to infer the exact age of the seed that produced the tree. The seeds of many tree species can remain dormant for several years before germinating. Only after germination and the subsequent development of growth rings can the trees be dated. Therefore, germination dates may not reflect the exact timing of seed mast years.

METHOD

The clear anatomical distinction between the structure of the root (protostele) and the shoot (eustele) is the basis for determining the germination date of trees (Figure 1). The first step is to locate the root collar. The actual location of the root collar, and therefore the root/shoot interface, may be obscured by erosion or sedimentation (Telewski and Lynch 1991). In cases where the base of the tree has been buried by sediments or the soil eroded from around the roots, it will be more difficult to locate the interface zone. These conditions will require analysis of larger sections of the trunk to locate the germination date.

After the section of the tree containing the transition zone between root and shoot tissue has been identified, the next step is identification of shoot tissue with a pith (Figure 1a) and root tissue without a pith (Figure 1b). Locating the exact transition requires a systematic approach of very careful serial sectioning or sanding the root collar using an abbreviated method identical to that employed in stem analysis (Duff and Nolan 1953). It is not necessary to produce histological thin sections of the stem; however, it is necessary to produce a finely polished wood surface so the tissue types can be properly identified under magnification.

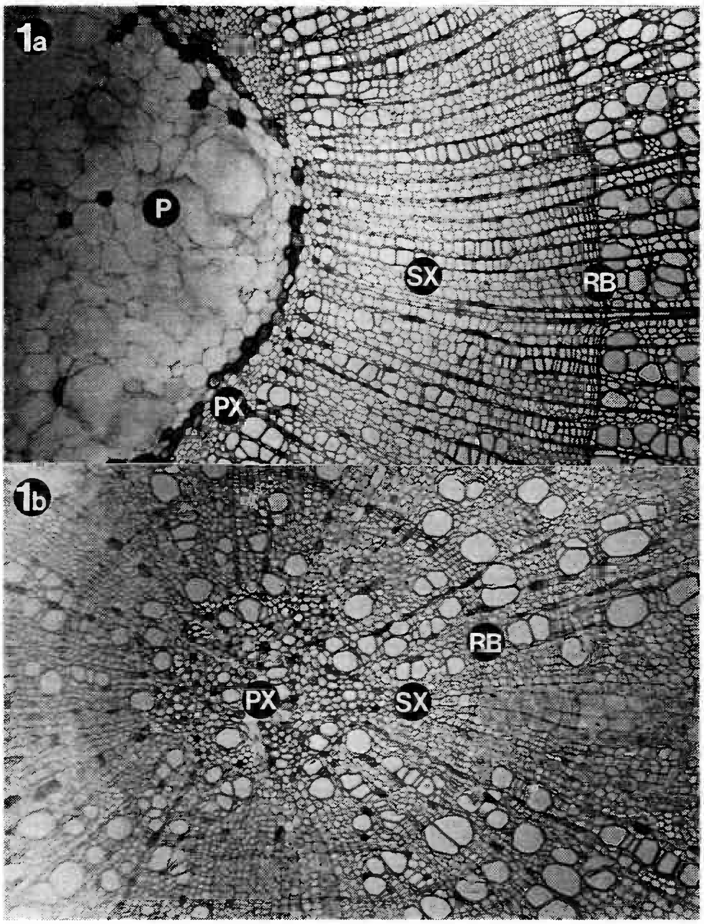

Figure 1. Transverse section of the stem (a) and root (b) of *Tilia americana* showing the pith (P), primary xylem (PX), secondary xylem (SX), and associated growth ring boundaries (RB).

The distance between the top of the last growth increment and the root/shoot interface depends on the amount of extension growth of the epicotyl (stem growth above the cotyledons) that occurred during the first year of growth and the extension of the hypocotyl. Conifers and small-seeded dicotylenous angiosperms, such as *Acer* and *Fraxinus*, produce an extended hypocotyl of up to two cm. Dicotylenous angiosperms with large nut-like seeds, such as *Quercus* and *Juglans*, do not produce an extended hypocotyl, only epicotyl growth during the first year. The height growth can be extensive in fast growing seedlings (in excess of one meter) or quite short in suppressed seedlings (Telewski and Lynch 1991). Some species of pine that possess a "seedling grass stage", such as *P. palustrus* (longleaf pine) and *P. arizonica* (Arizona longleaf pine), produce very little epicotyl extension growth for several years. The first several years of growth occur in the roots, favoring establishment of the young seedlings. Several years of height growth could be lost within a single chain saw cut.

At the first evidence of an absence of pith (or the first occurrence of a pith, if working from the bottom up) the section should be crossdated to verify the exact calendar date of the innermost growth ring. The distortion of growth rings at the root collar may complicate this analysis. It may be necessary to work only with the innermost series of concentric growth rings, produced prior to the tree attaining a large size and compression of the root collar by radically enlarging lateral roots.

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TREE-RING BULLETIN, *Vol. 53, 1993*

AN UPDATED LIST OF SPECIES USED IN TREE-RING RESEARCH

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ABSTRACT

During the past 100 years, researchers have investigated the potential of hundreds of tree and shrub species for use in applications of tree-ring research. Although several lists of species known to crossdate have been published, investigated species that do not crossdate are rarely included despite the usefulness of this information for future research. This paper provides a list of the Latin and common names of 573 species that have been investigated in tree-ring research, information on species known to crossdate, and information on species with measurement and/or chronology data in the International Tree-Ring Data Bank. In addition, a measure of the suitability of a species for future tree-ring applications, the Crossdating Index (CDI), is developed and proposed for standard usage.

In den letzten hundert Jahren haben Forscher das Potential von hunderten von Baum- und Buscharten für die Anwendung in der Jahresring-Forschung untersucht. Zahlreiche Listen mit Arten, von denen man weiβ, daβ sie zeitlich korrespondieren, sind bereits veröffentlicht worden, dagegen sind untersuchte Arten, die nicht zeitlich korrespondieren, selten in Publikationen berücksichtigt worden, obwohl diese Informationen für die künftige Forschung nutzvoll sein könnten. Dieser Artikel legt eine Liste der lateinischen und der gemeinen Namen von 573 Arten vor, die im Rahmen der Jahresring-Forschung untersucht worden sind, Informationen über Arten, die bekannterweise zeitlich korrespondieren sowie Informationen über Arten mit Maβ- und/oder Chronologiedaten in der internationalen Jahresring-Datenbank (International Tree-Ring Data Bank). Zudem wird in dem Artikel die Eignung der jeweiligen Art und ihre Bedeutung für die künftige Forschung beurteilt. Der hiermit entwickelte "Crossdating Index" (CDI) wird für den Standardgebrauch vorgeschlagen.

Au cours des cent dernières années, les chercheurs ont examiné le potentiel de centaines d'arbres et d'arbustes utilisables pour diverses applications dendrochronologiques. Bien que plusieurs listes de taxons connus pour être synchronisables aient été publiées, les espèces étudiées et qui se sont révélées non synchronisables, sont rarement mentionnées en dépit de l'utilité d'une telle information pour de futures recherches. Cet article donne la liste des noms latins et vernaculaires de 573 espèces étudiées du point de vue dendrochronologique et fournit des informations à propos de celles dont des mesures et des chronologies sont reprises dans la Banque Internationale de données dendrochronologiques (International Tree-Ring Data Bank). De plus, le coefficient de datation croisée (CDI) qui est une indication de l'utilité d'une espèce pour de futures applications dendrochronologiques est exposé et proposé pour un usage standard.

INTRODUCTION

For nearly 100 years, researchers have evaluated the tree-ring dating potential of hundreds of tree and shrub species for an extraordinarily wide range of applications in the earth and social sciences. These investigations have resulted in the publication of three lists of species used in tree-ring research, the first by Fritts (1976), the second by Cook and Kairiukstis (1990), and the third by Schweingruber (1993). Another comprehensive reference on species useful in tree-ring research is Hughes et al. (1982), whose contributing authors provided details on the crossdating potential and bibliographic references for species from all continents. However, these lists provide little or no information on species that have been investigated in tree-ring studies, but did not crossdate. Providing information on species that are not potentially useful in tree-ring research is important to scientists wishing to conduct research in areas where the major tree species used in dendrochronology may not be found (e.g. in tropical regions). Therefore, listing species that do not crossdate is as important as listing species that *do* crossdate.

The list I have compiled (Table 3) is a composite of all species listed in the previously mentioned volumes. In addition, I have listed additional species uncovered in an exhaustive search of a bibliographic database of more than 5,000 references on tree-ring research maintained and continuously updated on the computer facilities at the Laboratory of Tree-Ring Research in Tucson, Arizona. The purposes of this list are to:

(1) provide information on species with ring-growth parameters, (e.g. ring width and density) known to crossdate, and for which chronologies have been developed;
(2) provide information on species that have, at one time or another, been investigated but did not crossdate, or for which no information on crossdating is available;
(3) provide information on tropical and subtropical tree species that have had growth-ring characteristics examined;
(4) provide an updated list of standard four-letter codes for all species in the list;
(5) provide commonly used synonyms for certain species for cross-referencing purposes;
(6) list species that have had ring measurements and chronologies donated to the International Tree-Ring Data Bank (ITRDB).

The international tree-ring community would benefit greatly if information on species being investigated, or having been investigated, is contributed so that this list can be continuously updated. Contribution of this information is strictly voluntary, and should be sent to the author at the address listed above. For species new to the list, the full Latin name and authority and common name of the species should be contributed as well as information on how well any ring-growth parameters of the species crossdate. The four-letter species code will be designated by personnel of the ITRDB to all species investigated, including those that do not crossdate, should future researchers discover that those species do indeed crossdate. Contribution of ring-growth measurements and final chronologies for the species being investigated to the ITRDB is also voluntary but highly encouraged.

MAJOR TREE GENERA UTILIZED IN TREE-RING RESEARCH

Table 1 lists the major tree genera utilized in dendrochronology. By far, the genus most investigated is *Pinus* totaling 63 species investigated with at least 54 known to crossdate. These figures are not surprising because the pine species are among the world's most widely distributed botanical species with a very high ecological amplitude, capable of growing in all Northern Hemisphere latitudes from the equator to 70° north and all elevations to treeline (Critchfield and Little 1966; Mirov 1967; Vidakovic 1991). The second most investigated tree genus is *Quercus* with 44 species having been investigated in tree-ring studies, 27 of which are known to crossdate. The firs (*Abies*) rank third with 21 species known to crossdate, while the spruces (*Picea*) rank fourth with 19 species known to crossdate. The junipers (*Juniperus*) rank fifth with 15 species known to crossdate. Despite the limited distribution of the southern beech species (*Nothofagus*), the number of species investigated (12) is surprising and illustrates the importance of this genus for investigating the dynamics of Southern Hemisphere hardwood forests (Gutiérrez 1992; Norton 1985; Veblen et al. 1992).

Table 1. Important genera of tree species used in tree-ring research ranked by the number of species currently known to crossdate for each genus.

Rank	Genus	Number of Species Investigated	Number of Species that Crossdate
1	*Pinus*	63	54
2	*Quercus*	44	27
3	*Abies*	34	21
4	*Picea*	21	19
5	*Juniperus*	21	15
6	*Larix*	9	9
7	*Populus*	10	7
8	*Nothofagus*	12	7
9	*Acer*	10	6
10	*Dacrydium*	5	5
11	*Betula*	13	5
12	*Tsuga*	7	5
13	*Cedrus*	4	4

THE CROSSDATING INDEX (CDI)

The international tree-ring community should develop and standardize usage of an index that indicates the degree and/or strength of crossdating for a particular species. Some indices to measure dendrochronological potential have already been developed (Dyer 1982), but they have not been widely used by dendrochronologists. Such an index should be simple to use and readily interpretable by researchers worldwide. I propose a simple index, known as the Crossdating Index, or CDI, which is outlined in Table 2.

The CDI is based on the ability of a particular species to crossdate between trees at any one site (CDI = 1), and between sites in any one region (CDI = 2). A CDI of one indicates a species of minor importance in dendrochronology yet perhaps capable of yielding information on a site-by-site basis (e.g. *Juniperus thurifera* and *Tetraclinis articulata* [Schweingruber 1993]). A CDI of two indicates a species that crossdates between sites in a region and therefore exhibits the greatest potential for dendrochronological analyses on a regional basis (e.g. *Picea abies* and *Pseudotsuga menziesii* [Schweingruber 1993]). Two interpretations are possible for species with a CDI of zero. First and foremost, it indicates a species currently not known to crossdate and therefore to be of little or no use in dendrochronology. Second, it may also indicate a species that has been investigated but for which no information on crossdating potential and suitability for dendrochronological analyses was given by the original investigators.

The success of the CDI as a measure of the crossdating ability of a species depends on its continuous use by dendrochronologists. If a new species is being investigated, the principal investigators should report the CDI for the species along with the other pertinent statistical information for the species, such as the mean sensitivity, standard deviation, and autocorrelation of the measured series and final chronology. In addition, the CDI will inform researchers unfamiliar with dendrochronology of the suitability and importance of any particular species for tree-ring dating.

Table 2. The crossdating index, or CDI, indicating the degree to which a ring-growth parameter of a particular species can be crossdated.

CDI Value	Meaning of the CDI
0	Species does not crossdate, or no information on crossdating for this species has been published. NO OR LITTLE IMPORTANCE IN DENDROCHRONOLOGY.
1	Species is known to crossdate between cores from the same tree as well as between trees from the same site (between-tree crossdating), representing a species useful for interpreting local site conditions. MINOR IMPORTANCE IN DENDROCHRONOLOGY.
2	Species is known to crossdate between sites in a region (between-site crossdating), and represents a species of major importance in dendrochronology due to a strong macroclimatic signal that will yield information on a regional scale. MAJOR IMPORTANCE IN DENDROCHRONOLOGY.

SUGGESTIONS FOR RESEARCHERS

The literature on tree-ring research is replete with major inconsistencies in listing tree species, a problem that plagues most biological endeavors as new tree taxa are discovered or reclassified. Researchers should *always*, without fail, list which tree species are being investigated or utilized. This rule is perhaps the easiest to follow, yet is the most violated in tree-ring research. In addition to giving the full Latin name of the species being investigated or used (after which the genus name may be abbreviated), the researcher should also list the author (also called the "authority" or "namer of the tree") because this is considered part of the full technical name for any particular species. When preparing material for publication, however, researchers should follow guidelines for the particular medium being considered. Researchers should strive to use the most recent nomenclature for a particular taxon, though reclassification and renaming of taxa will always cause some inconsistencies. Archaic names should be avoided (for example, *Sequoiadendron giganteum* should be used instead of *Sequoia gigantea*).

ACKNOWLEDGMENTS

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Table 3. Species used in tree-ring research. Nomenclature follows Boland et al. (1984), Boutelje (1980), Coombs (1992), Little (1979), Perry (1991), Phillips (1978), Poole and Adams (1990), Schweingruber (1993), Vaucher (1986), and Vidakovic (1991). An asterisk (*) indicates that measurements and chronologies for this species are contained in the holdings of the ITRDB.

CDI	Code	Latin Name, Authority, and Common Name
	ABSP	*Abies* Mill. fir
2	ABAL	*Abies alba* Mill. silver fir, European fir
1	ABAM*	*Abies amabilis* Dougl. ex Forbes Pacific silver fir
2	ABBA	*Abies balsamea* (L.) Mill. balsam fir
1	ABBO*	*Abies borisii-regis* Mattf. Bulgarian fir, King Boris fir
0	ABBN	*Abies bornmuelleriana* Mattf. Bornmueller's fir
0	ABBR	*Abies bracteata* (D.Don) Nutt. bristlecone fir
1	ABCE*	*Abies cephalonica* Loud. Greek fir
0	ABCH	*Abies chensiensis* van Tiegh Chensien fir
1	ABCI	*Abies cilicica* (Ant. & Kotschy) Carr. Cilician fir
2	ABCO*	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr. white fir
0	ABEQ	*Abies equi-trojani* Aschers. & Sint.
		Abies ernestii Rehd. = *Abies recurvata* var. *ernestii* (Rehd.) Kuan
0	ABFX	*Abies faxoniana* Rehd. & Wils. Faxon fir
0	ABFI	*Abies firma* Sieb. & Zucc. Japanese fir, Momi fir
1	ABFO	*Abies forestii* Rogers Chinese fir
1	ABFR	*Abies fraseri* (Pursh) Poir. Fraser fir
1	ABGR	*Abies grandis* (Dougl. ex D. Don) Lindl. grand fir, giant fir
0	ABHO	*Abies holophylla* Maxim. Manchurian fir
1	ABKO	*Abies koreana* Wils. Korean fir
2	ABLA*	*Abies lasiocarpa* (Hook.) Nutt. subalpine fir, corkbark fir

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
1	ABMA	*Abies magnifica* A. Murr. Califomia red fir
1	ABMC	*Abies marocana* Trabut Moroccan fir
0	ABNB	*Abies nebrodensis* (Lojac.) Mattei Sicilian fir
0	ABNE	*Abies nephrolepis* Maxim. East Siberian fir
1	ABNO*	*Abies nordmanniana* (Stev.) Spach Caucasian fir
1	ABNU	*Abies numidica* De Lannoy ex. Carr. Algerian fir
1	ABPI*	*Abies pindrow* (Royle) Spach Himalayan silver fir, West Himalayan fir
1	ABPN*	*Abies pinsapo* Boiss. Spanish fir
1	ABPR*	*Abies procera* Rehd. noble fir
1	ABRC	*Abies recurvata* Mast. Min fir
0	ABRE	*Abies religiosa* Schlecht. Mexican fir, sacred fir
0	ABSA	*Abies sachalinensis* (Schmidt) Mast. Sachalin fir, todo
0	ABSI	*Abies sibirica* Ledeb. Siberian fir
1	ABSB*	*Abies spectabilis* (D. Don) Spach silver fir, East Himalayan fir
0	ABVI	*Abies vietchii* Lindl. Vietch's silver fir
0	ACAL	*Acacia alpina*
0	ACCA	*Acacia catechu* Willd. cutch, Indian acacia
0	ACGI	*Acacia giraffae* Willd. camel thom
0	ACHO	*Acacia hotwittii*
0	ACME	*Acacia melanoxylon* R.Br. blackwood
0	ACRA	*Acacia raddiana* Savia Israelian acacia
	ACSP	*Acer* L. maple
1	ACCA	*Acer campestre* L. hedge maple, field maple
0	ACNE	*Acer negundo* L. boxelder, ash-leaved maple
1	ACOP	*Acer opalus* Mill. Italian maple
0	ACPE	*Acer pensylvanicum* L. striped maple
1	ACPL	*Acer platanoides* L. Norway maple
1	ACPS	*Acer pseudoplatanus* L. sycamore maple, plane tree
1	ACRU	*Acer rubrum* L. red maple
0	ACSA	*Acer saccharinum* L. silver maple

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
2	ACSH*	*Acer saccharum* Marsh. sugar maple
0	ACSC	*Acer spicatum* Lam. mountain maple
0	ADDI	*Adansonia digitata* L. baobab, monkey bread tree
0	ADFA	*Adenostoma fasciculatum* Hook. & Arn. chamise, greasewood
1	ADHO*	*Adesmia horrida* Gill.
1	ADUS*	*Adesmia uspallatensis* Gill.
0	AEHI	*Aesculus hippocastanum* L. horse chestnut
0	AEPU	*Aextoxicon punctatum* R. & Pav. olivillo, tique
0	AFAF	*Afzelia africana* Smith afzelia, apa, doussie, alinga, papao
2	AGAU*	*Agathis australis* (D. Don) Lindley kauri pine
0	AGMA	*Agathis macrophylla* Fijian kauri
0	AGMO	*Agathis moorei* Mast. kauri
0	AGPA	*Agathis palmerstoni* F.v.M. North Queensland kauri, Australian agathis
2	AGRO	*Agathis robusta* (C. Moore ex F. Muell) Bailey kauri pine, Queensland kauri
0	AGVI	*Agathis vitiensis* (Seeman) Benth. & Hook.f. ex Drake Fiji kauri, dakua
0	AIAL	*Ailanthus altissima* (Mill.) Swingle Tree of Heaven
	ALSP	*Alnus* Mill. alder *Alnus crispa* = *Alnus viridis* var. *crispa* (Ait.) Turrill
1	ALGL	*Alnus glutinosa* (L.) Gaertn. common alder, European alder, black alder
1	ALIN	*Alnus incana* (L.) Moench grey alder, white alder
0	ALMA	*Alnus maximowiczii* Callier
0	ALRH	*Alnus rhombifolia* Nutt. white alder
0	ALRU	*Alnus rubra* Bong. red alder
0	ALRG	*Alnus rugosa* (Du Roi) Spreng. speckled alder, rough alder
0	ALSE	*Alnus serrulata* (Ait.) Willd. hazel alder
0	ALSI	*Alnus sinuata* (Regel.) Rydb. Sitka alder
1	ALVI	*Alnus viridis* (Chaix) DC. in Lam. & DC. green alder
0	ALCR	*Alnus viridis* var. *crispa* (Ait.) Turrill American green alder
1	AMSP	*Amelanchier* Medik. serviceberry
0	AMLU	*Amomyrtus luma* (Mol.) Legr. & Kaus. luma
	ARSP	*Araucaria* A.L. Juss. araucaria

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
1	ARAN	*Araucaria angustifolia* (Bertol.) Kuntze Parana araucaria, Parana pine, candelabra tree
2	ARAR*	*Araucaria araucana* (Molina) K. Koch monkey puzzle, araucaria, pehuen, Chile pine
0	ARBI	*Araucaria bidwilli* Hook. bunya pine, bunya
0	ARCU	*Araucaria cunninghamii* Aiton ex D. Don hoop pine, Moreton bay pine, colonial pine
0	ARHE	*Araucaria heterophylla* (Salisb.) Franco Norfolk Island pine
0	ARHU	*Araucaria hunsteinii* Klinki pine
0	ARGL	*Arctostaphylos glauca* Lindl. bigberry manzanita
1	ARTR	*Artemisia tridentata* Nutt. big sagebrush
2	ATCU*	*Athrotaxis cupressoides* D. Don pencil pine, smooth Tasmanian cedar
2	ATSE*	*Athrotaxis selaginoides* D. Don King Billy pine
2	AUCH*	*Austrocedrus chilensis* (D. Don) Florin & Boutelje Chilean cedar, cipres de la cordillera, Chilean incense cedar
0	BAAE	*Balanites aegyptiaca* Del. Jericho balsam, heglig
0	BLTA	*Beilschmiedia tawa* (A. Cunn.) Kirk tawa
0	BTEX	*Bertholletia excelsa* H.B.K. Brazil nut, yuvia, turury, para nut tree
	BESP	*Betula* L. birch
0	BEAB	*Betula albosinensis* Burk. Chinese birch
1	BEAL	*Betula alleghaniensis* Britton yellow birch
		Betula carpatica Walldst. & Kit. ex Willd. = *Betula pubescens* var. *carpatica* (Willd.) Ascherson & Graebner Carpathian birch
0	BEER	*Betula ermanii* Cham. Japanese birch, dakekaba
0	BEGL	*Betula glandulosa* Michx. bog birch, dwarf birch
0	BELE	*Betula lenta* L. sweet birch, black birch
0	BENI	*Betula nigra* L. river birch
1	BEPA	*Betula papyrifera* Marsh. paper birch
1	BEPE	*Betula pendula* Roth = *Betula verrucosa* Ehrl. silver birch, European white birch
0	BEPL	*Betula platyphylla* Suk. jagjag-namu, Japanese birch
0	BEPO	*Betula populifolia* Marsh. gray birch
1	BEPU	*Betula pubescens* Ehrh. downy birch, mountain birch, white birch
0	BEUT	*Betula utilis* D.Don Himalayan birch

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
1	BEVE	*Betula verrucosa* Ehrl. silver birch, European white birch
0	BOMA	*Bombax malabaricum* DC. semul, ngiu, ngiew, gon run do
0	BUSI	*Bursera simaruba* (L.) Sarg. gumbo-limbo, West-Indian birch
1	BUSE	*Buxus sempervirens* L. common box, boxwood
	CASP	*Callitris* Ventenat
0	CACO	*Callitris columellaris* F. Muell. cypress pine
0	CAIN	*Callitris intratropica* R.T. Baker & H.G. Smith cypress pine
0	CAMA	*Callitris macleayana* (F. Muell.) F. Muell brush cypress pine
1	CAPR	*Callitris preissii* Miq. Rottnest Island pine
1	CARO	*Callitris robusta* R. Br. ex Bailey = *Callitris preissii* Miq. Rottnest Island pine
1	CADE	*Calocedrus decurrens* (Torr.) Florin California incense cedar
0	CPBE	*Carpinus betulus* L. hornbeam
	CYSP	*Carya* Nutt. hickory
0	CYCO	*Carya cordoformis* (Wangenh.) K. Koch bitternut hickory
1	CYGL	*Carya glabra* (Mill.) Sweet pignut hickory
1	CYIL	*Carya illinoensis* (Wagenh.) K. Koch pecan
0	CYOV	*Carya ovata* (Mill.) K. Koch shagbark hickory
0	CYTO	*Carya tomentosa* (Poir.) Nutt. mockernut hickory
0	CACR	*Castanea crenata* Sieb. & Zucc. Japanese chestnut
1	CASA	*Castanea sativa* Mill. sweet chestnut, European chestnut
0	CSLI	*Casuarina litoralis* Salisb. black she-oak
0	CSVE	*Casuarina verticillata*
0	CTSP	*Catalpa speciosa* Warder ex Engelm. northern catalpa
0	CNCR	*Ceanothus crassifolius* Torr. hoaryleaf ceanothus
	CESP	*Cedrela* spp.
1	CEAN*	*Cedrela angustifolia* Sesse & Mocino ex DC. cedro salteno
		Cedrela balansae C. DC. = *Cedrela angustifolia* Sesse & Mocino
0	CEFI	*Cedrela fissilis* Vell. central American cedar, cigarbox cedar
1	CELI*	*Cedrela lilloi* C. DC. cedro salteno
0	CETO	*Cedrela toona* Roxb. ex. Rottler = *Toona australis* (F. Muell.) Harms red cedar, Australian cedar, toon, yomhom

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
	CDSP	*Cedrus* Trew cedar
2	CDAT	*Cedrus atlantica* (Endl.) Manetti Atlantic cedar, Atlas cedar
1	CDBR*	*Cedrus brevifolia* Henry = *Cedrus libani* var. *brevifolia* Cyprian cedar
1	CDDE	*Cedrus deodara* (D. Don) G. Don deodar cedar, Himalayan cedar
1	CDLI	*Cedrus libani* A. Richard Cedar of Lebanon
	CLSP	*Celtis* L. hackberry
0	CLLA	*Celtis laevigata* Willd. sugarberry
1	CLOC	*Celtis occidentalis* L. hackberry
0	CEOC	*Cephalanthus occidentalis* L. buttonbush
	CRSP	*Cercocarpus* Kunth cercocarpus
0	CRBE	*Cercocarpus betuloides* Nutt. birchleaf mountain-mahogany
0	CRLE	*Cercocarpus ledifolius* Nutt. curlleaf mountain-mahogany
1	CRMO	*Cercocarpus montanus* Raf. alderleaf cercocarpus
0	CHNO	*Chamaecyparis nootkatensis* (D. Don) Spach Alaska yellow-cedar, Nootka cypress
1	CHOB	*Chamaecyparis obtusa* (Sieb. & Zucc.) Endl. hinoki cypress, Formosan cypress
0	CHTH	*Chamaecyparis thyoides* (L.) B.S.P. Atlantic white-cedar
0	CLEX	*Chlorophora excelsa* Benth. & Hook.f. iroko, kambala, mvule
0	CHSP	*Chorisia speciosa* St. Hil. paneira
0	CIFR	*Citharexylum fruticosum* L. Florida fiddlewood
0	COCO	*Copaifera coleosperma* Benth. Rhodesian copalwood, mehibi
	CONI	Various conifers
0	COTR	*Cordia trichotoma* Vell. lauro pardo, peterebi
0	COAL	*Cordia alliodora* Oken laurel corriente, lauro amarillo, ajo ajo
	COSP	*Cornus* L. dogwood
0	COFL	*Cornus* florida L. flowering dogwood
0	COAV	*Corylus avellana* L. common hazel
0	CRAZ	*Crataegus azarolus* L. azarole
2	CMJA*	*Cryptomeria japonica* (L. f.) D. Don Japanese cedar, sugi, cryptomeria
1	CUAZ	*Cupressus arizonica* Greene Arizona cypress
0	CUDU	*Cupressus dupreziana* Camus

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
1	CUGI	*Cupressus gigantea* Cheng & L.K. Fu
0	CUGL	*Cupressus glabra* Sudworth smooth Arizona cypress
		Cupressus lindleyi Klotzsch. = *Cupressus lusitanica* Mill.
0	CULU	*Cupressus lusitanica* Mill. Mexican cypress
2	CUSE	*Cupressus sempervirens* L. Italian cypress, Mediterranean cypress
0	CYRA	*Cyrilla racemiflora* L. swamp cyrilla, leatherwood
0	DADA	*Dacrycarpus dacrydioides* (A. Rich.) Laubenf. kahikatea, white pine
1	DABD	*Dacrydium bidwillii* New Zealand mountain pine
1	DABI*	*Dacrydium biforme* (Hook.) Pilger = *Halocarpus biformis* Hook. pink pine
1	DACO*	*Dacrydium colensoi* Hook. = *Lagarostrobos colensoi* (Hook.) C.J. silver pine
2	DACU	*Dacrydium cupressinum* Lamb. rimu, red pine
1	DAFR	*Dacrydium franklinii* Hook f. Huon pine
0	DSVI	*Diospyros virginiana* L. common persimmon
0	DITO	*Discaria toumatou* Raoul matagouri, tumatu-kuru, wild Irishman
1	DITR	*Discaria trinervis* Reiche.
0	DRLA	*Dracophyllum latifolium* Cunn. neinei
0	DRWI	*Drimys winteri* J.R. & G. Forst canelo, winter bark
1	DUVI	*Duschenkia viridis* Opiz = *Betula ovata* Schrank.
0	DYMA	*Dysoxylum malabaricum* Bedd. Bombay white cedar, Indian white cedar
0	ELGL	*Elaeoluma glabrascens*
1	EMRU	*Empetrum rubrum* Vahl ex. Willd. murtilla
0	ENAN	*Entandrophragma angolense* C.DC. gedu nohor, kalungi, tiama, edinam
0	ENCA	*Entandrophragma candollei* Harms kosipo, omu, entandrophragma mahogany
0	ENCY	*Entandrophragma cylindricum* Sprague sapeli,sapele, sapelli, assi
		Entandrophragma macrophyllum A. Chev. = *Entandrophragma angolense* C.DC.
0	ENUT	*Entandrophragma utile* Sprague sipo, utile
	EPSP	*Ephedra* L.
0	EUCA	*Eucalyptus camaldulensis* Dehnh. river red gum
0	EUDE	*Eucalyptus delegatensis* R. Baker alpine ash
0	EUMI	*Eucalyptus miniata* Cunn. ex Shauer Darwin woolybutt
0	EUNE	*Eucalyptus nesophila* Blakely Melville Island bloodwood

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	EUOR	*Eucalyptus oreades* R.T. Baker Blue Mountains ash
0	EUPA	*Eucalyptus pauciflora* Sieb. snow gum, cabbage gum
0	EUST	*Eucalyptus stellulata* Sieb. ex DC black salee
0	EUTE	*Eucalyptus tetradonta* F. Muell. Darwin stringybark
0	EUVI	*Eucalyptus viminalis* Labill. ribbongum
0	EUCO	*Eucryphia cordifolia* Cav. ulmo, muermo
0	EUJA	*Eugenia jambolana* Lam. jaman, kelat eugenia
0	EXCU	*Exocarpus cuppressiforme* Labill. native cherry
	FASP	*Fagus* L. beech
1	FAGR*	*Fagus grandifolia* Ehrh. American beech
1	FAOR	*Fagus orientalis* Lipsky Oriental beech, eastern beech
2	FASY	*Fagus sylvatica* L. European beech, common beech
	FCSP	*Ficus* L. fig
2	FICU*	*Fitzroya cupressoides* (Molina) Johnston alerce, Patagonian cypress
	FRSP	*Fraxinus* L. ash
1	FRAM	*Fraxinus americana* L. white ash
0	FRCA	*Fraxinus caroliniana* Mill. Carolina ash
1	FREX	*Fraxinus excelsior* L. European ash, common ash
1	FRNI	*Fraxinus nigra* Marsh. black ash
0	FRPE	*Fraxinus pennsylvanica* Marsh. green ash, red ash
0	GEAV	*Gevuina avellana* avellano
0	GIBI	*Gingko biloba* L. maidenhair tree, gingko
0	GLTR	*Gleditsia triacanthos* L. honey locust
0	GMAR	*Gmelina arborea* Roxb. gumari, gumbar, yemane, gmelina, gamari
0	GOLA	*Gordonia lasianthus* (L.) Ellis loblolly-bay
0	GRVI	*Grevillea victoriae* F. Muell.
0	GUCE	*Guarea cedrata* Pellegr. bosse, guarea, white guarea, scented guarea
0	HABD	*Halocarpus bidwillii* bog pine
1	HABI*	*Halocarpus biformis* (Hook.) Quinn pink pine
0	HAKI	*Halocarpus kirkii* manoao
0	HAVI	*Hamamelis virginiana* L. witch hazel

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	HEAN	*Hedycaria angustifolia* A. Cunn. native mulberry
0	HEAR	*Heteromeles arbutifolia* (Lindl.) M.J. Roem. toyon
0	ILAQ	*Ilex aquifolium* L. English holly
0	ILCA	*Ilex cassine* L. dahoon, dahoon holly
0	ILCO	*Ilex coriacea* (Pursh) Chapm. large gallberry, sweet gallberry
0	ILGL	*Ilex glabra* (L.) Gray inkberry, gallberry
0	ILIN	*Ilex inundata*
0	ILOP	*Ilex opaca* Ait. American holly
0	JACO	*Jacaranda copaia* D.Don copaia, gobaja, futui, caroba
1	JGAU*	*Juglans australis* Griseb. Argentine walnut
0	JGCI	*Juglans cinerea* L. buttemut
0	JGNI	*Juglans nigra* L. black walnut
0	JGRE	*Juglans regia* L. common walnut
	JUSP	*Juniperus* L. juniper
0	JUCH	*Juniperus chinensis* L. Chinese juniper
1	JUCO	*Juniperus communis* L. common juniper
0	JUDE	*Juniperus deppeana* Steud. alligator juniper
1	JUDR	*Juniperus drupacea* Labill. Syrian juniper
1	JUEX	*Juniperus excelsa* Bieb. Greek juniper, Grecian juniper
1	JUFO	*Juniperus foetidissima* Willd. stinking juniper
		Juniperus indica = *Juniperus semiglobosa* Regel
0	JUMA	*Juniperus macropoda* Boiss. Himalayan pencil pine
0	JUMO	*Juniperus monosperma* (Emgelm.) Sarg. one-seed juniper
2	JUOC*	*Juniperus occidentalis* Hook. westem juniper
1	JUOS	*Juniperus osteosperma* (Torr.) Little Utah juniper
1	JUOX	*Juniperus oxycedrus* L. prickly juniper
		Juniperus palycarpos = *Juniperus seravschanica* Komar.
1	JUPH	*Juniperus phoenicea* L. Phoenicean juniper
0	JUPI	*Juniperus pinchotii* Sudw. redberry juniper, Pinchot juniper
1	JUPR	*Juniperus przewalskii* Kom. Qilianshan juniper

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
1	JURE	*Juniperus recurva* Buch.-Ham. ex D. Don drooping juniper
2	JUSC*	*Juniperus scopulorum* Sarg. Rocky Mountain juniper
1	JUSM	*Juniperus semiglobosa* Regel
1	JUSE	*Juniperus seravschanica* Komar.
0	JUTH	*Juniperus thurifera* L. Spanish juniper
1	JUTU	*Juniperus turkestanica* Komar. Turkestan juniper
2	JUVI*	*Juniperus virginiana* L. eastern redcedar
0	KHGR	*Khaya grandifolia* C.DC. acajou, Benin mahogany, African mahogany
0	KRDR	*Krenevaja drevesina*
0	KUER	*Kunzea ericoides* (A. Rich.) J. Thompson kanuka, white tea tree
0	LBGL	*Labatia glomerata*
0	LBAN	*Laburnum anagyroides* Medik. common laburnum
1	LGCO*	*Lagarostrobus colensoi* (Hook.) C.J. Quinn = *Dacrydium colensoi* Hook.
1	LGFR	*Lagarostrobus franklinii* C.J. Quinn huon pine
0	LSFL	*Lagerstroemia flos-reginae* Retz. pyinma, banaba, banglang, jarul
0	LSPA	*Lagerstroemia parviflora* Roxb. lendia
0	LSLA	*Lagerstroemia lanceolata* Wall. benteak, nana
	LASP	*Larix* Mill. larch
		Larix cajanderi Mayr = *Larix gmelinii*
		Larix dahurica Turcz. ex Trautv. = *Larix gmelinii* (Rupr.) Litvin.
2	LADE*	*Larix decidua* Mill. European larch
1	LAGM*	*Larix gmelinii* (Rupr.) Litvin. Dahurian larch
1	LAGR	*Larix griffithiana* (Lindl. & Gord.) Carr. Himalayan larch
1	LAJA	*Larix japonica* Carr. Japanese larch
		Larix kaempferi (Lamb.) Carr. = *Larix japonica* Carr.
		Larix kurilensis Mayr = *Larix gmelinii* var. *japonica* (Regel) Pilg.
2	LALA*	*Larix laricina* (Du Roi) K. Koch tamarack, eastern larch
2	LALY*	*Larix lyallii* Parl. subalpine larch
2	LAOC*	*Larix occidentalis* Nutt. western larch
1	LAPO	*Larix potaninii* Batal. Chinese larch
		Larix russica (Endl.) Sabine ex Trautv. = *Larix sibirica* Ledeb.
2	LASI*	*Larix sibirica* Ledeb. Siberian larch
		Larix sukachevii Djil. = *Larix sibirica* Ledeb. Ural larch

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	LAPH	*Laurelia philippiana* Looser tepa
0	LASE	*Laurelia sempervirens* Tul. laurelia, Chilean laurel, huahuan
0	LEIN	*Lepidothamnus intermedius* (Kirk) Quinn yellow-silver pine
		Leptospermum ericoides = *Kunzea ericoides*
0	LEFL	*Leptospermum flavescens* tea tree
0	LESC	*Leptospermum scoparium* Forster & Forster f. manuka, red tea tree, black manuka, red manuka
	LISP	*Libocedrus* Endl. incense-cedar
2	LIBI*	*Libocedrus bidwillii* Hook. f. New Zealand cedar, pahautea, kaikawaka
		Libocedrus decurrens Torr. = *Calocedrus decurrens* (Torr.) Florin
0	LIPL	*Libocedrus plumosa* (D.Don) Sarg. kawaka, plume incense cedar
1	LIST	*Liquidambar styraciflua* L. sweetgum
1	LITU	*Liriodendron tulipifera* L. tuliptree, yellow-poplar, tulip-poplar
0	LOFR	*Lomatia fraseri* R.Br. silky lomatia, tree lomatia
0	LOHI	*Lomatia hitsuta* (Lam.) Diel ex. Macbr. radal
0	LOTR	*Lovoa trichilioides* Harms dibetou
0	MAAC	*Magnolia accuminata* L. cucumbertree
0	MAGR	*Magnolia grandiflora* L. southern magnolia
0	MAVI	*Magnolia virginiana* L. sweetbay, swampbay
0	MASY	*Malus sylvestris* L. apple tree
0	MICH	*Michelia champaca* L. champak
0	MINI	*Michelia niligirica* Zenker pilachampa, champak
	MIX	Various taxa
0	MOAL	*Morus alba* L. white mulberry
0	MORU	*Morus rubra* L. red mulberry
0	MYCE	*Myrica cerifera* L. southern bayberry, bayberry
0	MYGA	*Myrica gale* L. sweet gale, bog myrtle
0	NEAM	*Nectandra amazonum*
0	NTLO	*Notelaea longifolia* Vent. large mock-olive
0	NOAL	*Nothofagus alpina* (Poepp. & Endl.) OErst. rauli
1	NOAN	*Nothofagus antarctica* (Forst) Oerst. Antarctic beech, nirre
1	NOBE*	*Nothofagus betuloides* (Mirb.) Blume coihue de Magallanes, guindo

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	NOCU	*Nothofagus cunninghamii* Oerst. Australian nothofagus, myrtle beech
0	NODO	*Nothofagus dombeyi* (Mirb.) Blume coihue, Dombey's southern beech
0	NOFU	*Nothofagus fusca* (Hook. f.) Oerst. red beech, New Zealand red beech
1	NOGU*	*Nothofagus gunnii* (Hook. f.) Oerst. tanglefoot beech
2	NOME*	*Nothofagus menziesii* (Hook. f.) Oerst. silver beech, Menzies's red beech
0	NONI	*Nothofagus nitida* Reiche roble chicote
1	NOOB	*Nothofagus obliqua* (Mirb.) Blume southern beech, roble
1	NOPU*	*Nothofagus pumilio* (Poepp. & Endl.) Oerst. lenga
2	NOSO*	*Nothofagus solandri* (Hook. f.) Oerst. mountain beech, black beech
0	NYOG	*Nyssa ogeche* Bartr. ex Marsh. Ogeechee tupelo
0	NYSY	*Nyssa sylvatica* Marsh. black tupelo, blackgum
0	OSCA	*Ostrya carpinifolia* Scop. hop hornbeam
0	OXAR	*Oxydendrum arboreum* (L.) DC sourwood
0	PARI	*Parapiptadenia rigida* Benth.
0	PAAU	*Parkia auriculata*
0	PATO	*Paulownia tomentosa* (Thumb.) Steud. empress tree
0	PECA	*Peronema canescens* Jack. sunkai, koeroes
0	PEBO	*Persea borbonia* (L.) Spreng. redbay, shorebay
0	PELI	*Persea lingue* Nees lingue
0	PELN	*Petrophile linearis* R.Br. pixie mops
0	PBPO	*Phoebe porfiria* Mez.
1	PHAL*	*Phyllocladus alpinus* Hook. f. mountain toatoa, alpine celery top pine
1	PHAS*	*Phyllocladus aspleniifolius* (Labill.) Hook. f. celery top pine
1	PHGL*	*Phyllocladus glaucus* Carr. toatoa
1	PHTR*	*Phyllocladus trichomanoides* D. Don in Lamb. tanekaha, celery pine
	PCSP	*Picea* A. Dietr. spruce
2	PCAB*	*Picea abies* (L.) Karst. Norway spruce
		Picea ajanensis Fisch. = *Picea jezoensis* (Sieb. & Zucc.) Carr.
0	PCAS	*Picea asperata* Mast. dragon spruce
1	PCBA	*Picea balfouriana*
1	PCCA	*Picea cajanensis* Lindl. et Gord.
1	PCCH	*Picea chihuahuana* Martinez chihuahua spruce

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
2	PCEN*	*Picea engelmannii* Parry ex Engelm. Engelmann spruce *Picea excelsa* (Lam.) Link = *Picea abies* (L.) Karst
2	PCGL*	*Picea glauca* (Moench) Voss white spruce
1	PCGN	*Picea glehnii* (Fr. Schmidt) Mast. Sakhalin spruce
0	PCJE	*Picea jezoensis* (Sieb. & Zucc.) Carr. Yezo spruce, Hondo spruce
1	PCLI	*Picea likiangensis* (Franchet) Pritzel Likiang spruce
2	PCMA*	*Picea mariana* (Mill.) Britt., Sterns & Poggenb. black spruce
2	PCOB	*Picea obovata* Ledeb. Siberian spruce
1	PCOM*	*Picea omorika* (Panc.) Purk. Serbian spruce, Pancic spruce
1	PCOR*	*Picea orientalis* (L.) Link eastern spruce, Oriental spruce
2	PCPU*	*Picea pungens* Engelm. blue spruce, Colorado spruce
1	PCPR	*Picea purpurea* Mast.
2	PCRU*	*Picea rubens* Sarg. red spruce
1	PCSH	*Picea shrenkiana* Fisch. & Meyer Shrenk's spruce
2	PCSI*	*Picea sitchensis* (Bong.) Carr. Sitka spruce
1	PCSM	*Picea smithiana* (Wall.) Boiss. Himalayan spruce
1	PCTI	*Picea tienschanica* Rupr. Tien-shan spruce
2	PLUV*	*Pilgerodendron uviferum* (Pilger) Florin cipres de las Guaytecas
	PISP	*Pinus* L. pine
2	PIAL*	*Pinus albicaulis* Engelm. whitebark pine
2	PIAR*	*Pinus aristata* Engelm. in Parry & Engelm. Rocky Mountain bristlecone pine *Pinus aristata* var. *longaeva* = *Pinus longaeva* D.K. Bailey
1	PIAM	*Pinus armandii* Franchet David's pine, Armand's pine
2	PIBA*	*Pinus balfouriana* Grev. & Balf. in A. Murr. foxtail pine
2	PIBN	*Pinus banksiana* Lamb. jack pine
1	PIBR*	*Pinus brutia* Ten Calabrian pine, brutia pine, see kiefer
0	PIBU	*Pinus bungeana* Zucc. lacebark pine
0	PICN	*Pinus canariensis* Chr. Sm. ex DC Canary Island pine
0	PICA	*Pinus caribea* Mor. Caribbean pine, Cuban pine

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
2	PICE*	*Pinus cembra* L. Swiss stone pine, Arolla pine
2	PICM*	*Pinus cembroides* Zucc. Mexican pinyon, Mexican nut pine
1	PICH	*Pinus chihuahuana* Engelm. chihuahua pine
2	PICO*	*Pinus contorta* Dougl. ex Loud. lodgepole pine
0	PICL	*Pinus coulteri* D.Don Coulter pine, bigcone pine
1	PIDN	*Pinus densata*[1]
1	PIDE	*Pinus densiflora* Sieb. & Zucc. Japanese red pine
2	PIEC*	*Pinus echinata* Mill. shortleaf pine
2	PIED*	*Pinus edulis* Engelm. in Wisliz. pinyon, Colorado pinyon
1	PIEL	*Pinus elliottii* Engelm. slash pine
1	PIEN	*Pinus engelmannii* Carr. Apache pine
2	PIFL*	*Pinus flexilis* James limber pine
1	PIGE	*Pinus gerardiana* Wall. ex D. Don. chilgoza pine, Gerard's pine
2	PIHA*	*Pinus halepensis* Mill. Aleppo pine, Jerusalem pine
		Pinus hallii = *Podocarpus hallii* Kirk
1	PIHE	*Pinus heldreichii* Christ Heldreich's pine, panzer fohre
2	PIJE*	*Pinus jeffreyi* Grev. & Balf. in A. Murr. Jeffrey pine
1	PIKE	*Pinus kesiya* Royle ex Gordon Khasi pine
1	PIKO	*Pinus koraiensis* Sieb. & Zucc. Korean pine
		Pinus laricio Poir. = *Pinus nigra* Arnold
2	PILA*	*Pinus lambertiana* Dougl. sugar pine
		Pinus leiophylla var. *chihuahuana* (Engelm.) Shaw = *Pinus chihuahuana* chihuahua pine
2	PILE*	*Pinus leucodermis* Ant. Bosnian pine, greybark pine, pino loricato
2	PILO*	*Pinus longaeva* D.K. Bailey Intermountain bristlecone pine
		Pinus longifolia Roxb. = *Pinus roxburghii* Sarg.
1	PIMK	*Pinus merkusii* Jungh. & De Vriese Merkus pine, mindoro pine, Tenasserim pine
1	PIME	*Pinus mesogeensis* Fieschi & Gaussen cluster pine
2	PIMO*	*Pinus monophylla* Torr. & Frem. in Frem. singleleaf pinyon
		Pinus montana Mill. = *Pinus mugo* Turra
1	PIMC	*Pinus monticola* Dougl. ex D. Don in Lamb. western white pine
1	PIMU*	*Pinus mughus* Scop. = *Pinus mugo* Turra krummholz pine

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
1	PIMG	*Pinus mugo* Turra mountain pine, stone pine
0	PIMR	*Pinus muricata* D.Don bishop pine
2	PINI*	*Pinus nigra* Arnold Austrian pine, black pine
0	PIOC	*Pinus occidentalis* Swartz West Indian pine
0	PIOO	*Pinus oocarpa* Schiede Nicaraguan pitch pine, ocote pine
		Pinus pallasiana Lamb. = *Pinus nigra* Arnold
1	PIPA	*Pinus palustris* Mill. longleaf pine
0	PIPT	*Pinus patula* Schiede & Deppe Mexican weeping pine
1	PIPE*	*Pinus peuce* Griseb. Macedonian pine, Balkan pine
1	PIPI	*Pinus pinaster* Ait. maritime pine, cluster pine
2	PIPN*	*Pinus pinea* L. Italian stone pine, umbrella pine
2	PIPO*	*Pinus ponderosa* Dougl. ex Laws. ponderosa pine, western yellow pine
1	PIPM	*Pinus pumila* (Pall.) Regel dwarf Siberian pine, Japanese stone pine
1	PIPU*	*Pinus pungens* Lamb. Table Mountain pine
1	PIQU	*Pinus quadrifolia* Parl. ex Sudw. Parry pinyon
1	PIRA	*Pinus radiata* D. Don Monterrey pine
2	PIRE*	*Pinus resinosa* Ait. red pine
1	PIRI*	*Pinus rigida* Mill. pitch pine
1	PIRO	*Pinus roxburghii* Sarg. chir pine
1	PISI	*Pinus sibirica* Du Tour Siberian stone pine
2	PISF	*Pinus strobiformis* Engelm. in Wisliz. southwestern white pine
2	PIST*	*Pinus strobus* L. eastern white pine, Weymouth pine
2	PISY*	*Pinus sylvestris* L. Scots pine, Scotch pine
1	PITB	*Pinus tabulaeformis* Carr. Chinese pine
2	PITA	*Pinus taeda* L. loblolly pine
0	PITH	*Pinus thunbergii* Parl. Japanese black pine
2	PIUN	*Pinus uncinata* Mill. ex Mirb. in Buffon mountain pine
1	PIVI	*Pinus virginiana* Mill. Virginia pine, scrub pine
1	PIWA	*Pinus wallichiana* A.B. Jackson Himalayan pine, kail pine, blue pine
0	PSGR	*Pisonia grandis*
	PTSP	*Pistacia* L. pistache

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	PTAT	*Pistacia atlantica* Desf. Atlas pistache, betoum
0	PTKH	*Pistacia khinjuk* Stocks. kakkar
0	PTPA	*Pistacia palaestina* Boiss. Israelian pistache
0	PTVE	*Pistacia vera* L. green mastic, real mastictree
0	PLAC	*Platanus acerifolia* (Ait.) Willd. London plane tree
1	PLOC	*Platanus occidentalis* L. American sycamore
1	PLOR	*Platyeladus orientalis* Chinese pine
0	PYSA	*Polyscias sambucifolius* (Sieber ex DC.) Harms elderberry panax, elderberry ash
	POSP	*Podocarpus* L'Heritier ex Persoon *Podocarpus dacrydioides = Dacrycarpus dacrydioides*
0	POFA	*Podocarpus falcatus* (Thumb.) Br. yellowwood, oteniqua *Podocarpus ferrugineus = Prumnopitys ferruginea* (D. Don) Laubenf.
0	POHA	*Podocarpus hallii* Kirk Hall's totara
0	POLA	*Podocarpus lawrencei* Hook. f. Tasmanian podocarpus
0	PONI	*Podocarpus nivalis* Hook. snow totara
1	PONU	*Podocarpus nubigensus* Lindl. ex Paxt manio de hojas punzantes, manio macho
0	POPA	*Podocarpus parlatorei* *Podocarpus spicatus = Prumnopitys taxifolia* (D. Don) Laubenf.
0	POTO	*Podocarpus totara* D. Don totara
	PPSP	*Populus* L. cottonwood, poplar
1	PPAL	*Populus alba* L. white poplar
0	PPAN	*Populus angustifolia* James narrowleaf cottonwood
1	PPBA	*Populus balsamifera* L. balsam poplar
0	PPDE	*Populus deltoides* Bartr. ex Marsh. eastern cottonwood
1	PPEU	*Populus euphratica* Oliv. charab poplar, Indian poplar
1	PPFR	*Populus fremontii* Wats. Fremont cottonwood
1	PPGR	*Populus grandidentata* Michx. bigtooth aspen
1	PPNI	*Populus nigra* L. black poplar
1	PPTR	*Populus tremuloides* Michx. quaking aspen
0	PPTC	*Populus trichocarpa* Torr. & Gray. black cottonwood
	PROS	*Prosopis* L. mesquite

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
1	PRFL	*Prosopis flexuosa* DC.
0	PRGL	*Prosopis glandulosa* Torr. honey mesquite
0	PMAN	*Prumnopitys andina* = *Podocarpus andinus* lleuque
0	PMFE	*Prumnopitys ferruginea* (D. Don) Laubenf. miro
0	PMTA	*Prumnopitys taxifolia* (D. Don) Laubenf. matai, black pine
0	PNAM	*Prunus americana* Marsh. American plum
0	PNAV	*Prunus avium* L. wild cherry
0	PNIL	*Prunus ilicifolia* (Nutt. ex Hook & Am.) D. Dietr. hollyleaf cherry
0	PNPE	*Prunus pennsylvanica* L.f. pin cherry
1	PNSE	*Prunus serotina* Ehrh. black cherry
0	PSMU	*Pseudobombax munguba* Mart. & Zucc. muguba, huira
1	PSMA*	*Pseudotsuga macrocarpa* (Vasey) Mayr bigcone Douglas-fir
2	PSME*	*Pseudotsuga menziesii* (Mirb.) Franco Douglas-fir
0	PSAX	*Pseudowintera axillaris* (Forster & Forster f.) Dandy horopito
0	PSCO	*Pseudowintera colorata* (Raoul) Dandy mountain horopito, pepper tree
0	PSXA	*Pseudoxandra polyphleba*
0	PTAN	*Pterocarpus angolensis* DC. muninga, mninga, brown African padauk
	PUSP	*Purshia* DC. ex Poir.
1	PUTR	*Purshia tridentata* (Pursh) DC. bitter brush
	QUSP	*Quercus* L. oak
0	QUAF	*Quercus afares* Pomel
2	QUAL*	*Quercus alba* L. white oak
0	QUBO	*Quercus boissieri* Reut. Israelian oak
0	QUCL	*Quercus calliprinos* Webb Kermes oak, Israelian oak
1	QUCA	*Quercus canariensis* Willd. Mirbeck's oak, Algerian oak
1	QUCE	*Quercus cerris* L. Turkey oak, Austrian oak
1	QUCO	*Quercus coccinea* Muenchh. scarlet oak
0	QUCP	*Quercus copeyensis*
0	QUCR	*Quercus costaricensis*
1	QUDG	*Quercus douglasii* Hook. and Am. blue oak
1	QUDS	*Quercus dschoruchensis* K. Koch
1	QUEL	*Quercus ellipsoidalis* E.J. Hill northern pin oak
0	QUEM	*Quercus emoryi* Torr. in Emory Emory oak

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	QUEN	*Quercus engelmannii* Greene Engelmann oak
1	QUFG	*Quercus faginea* Lam. Portuguese oak
1	QUFA	*Quercus falcata* Michx. southern red oak
0	QUFR	*Quercus frainetto* Ten. Hungarian oak
2	QUGA	*Quercus gambelii* Nutt. Gambel oak
1	QUGR	*Quercus grisea* Liebm. gray oak
1	QUHA	*Quercus hartwissiana*
0	QUIL	*Quercus ilex* L. holm oak, holly oak
0	QUIT	*Quercus ithaburensis* (Decne.) Boiss. Mt. Tabor oak
0	QUKE	*Quercus kelloggii* Newb. California black oak
1	QULA	*Quercus laurifolia* Michx. laurel oak
1	QULO	*Quercus lobata* Nee valley oak
1	QULY*	*Quercus lyrata* Walt. overcup oak
1	QUMA*	*Quercus macrocarpa* Michx. bur oak
0	QUML	*Quercus marilandica* Muenchh. blackjack oak
0	QUMI	*Quercus michauxii* Walt. swamp chestnut oak
0	QUMO	*Quercus mongolica* Fisch. ex Turcz. Mongolian oak
0	QUMU	*Quercus muehlenbergii* Engelm. chinkapin oak
1	QUNI	*Quercus nigra* L. water oak
		Quercus pagodaefolia (Ell.) Ashe = *Quercus falcata* var. *pagodifolia* Ell.
0	QUPA	*Quercus palustris* Muenchh. pin oak
		Quercus pedunculata Ehrl. = *Quercus robur* L.
1	QUPS	*Quercus persica*
2	QUPE*	*Quercus petraea* (Mattuschka) Liebl. durmast oak, sessile oak
1	QUPO	*Quercus pontica* K. Koch Armenian oak
1	QUPR*	*Quercus prinus* L. chestnut oak
2	QUPU	*Quercus pubescens* Willd. downy oak, pubescent oak
2	QURO*	*Quercus robur* L. English oak
1	QURU*	*Quercus rubra* L. red oak
		Quercus sessiliflora Salisb. = *Quercus petraea* (Mattuschka) Liebl.
1	QUSH	*Quercus shumardii* Buckl. Shumard oak
2	QUST*	*Quercus stellata* Wangenh. post oak

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	QUSU	*Quercus suber* L. cork oak, cork tree
1	QUVE*	*Quercus velutina* Lam. black oak
0	QUAC	*Quintinia acutifolia* Kirk. Westland quintinia
0	RAGU	*Rapanea guianensis* Aubl. guiana rapanea
0	RHCA	*Rhamnus caroliniana* Walt. Carolina buckthorn
0	RHCR	*Rhamnus crocea* Nutt. hollyleaf buckthorn
0	RHOV	*Rhus ovata* Wats. sugar sumac
1	RONE	*Robinia neomexicana* Gray New Mexico locust
0	ROPS	*Robinia pseudoacacia* L. black locust
0	SBPI	*Sabina pingu*
		Sabina przewalskii Kom. = *Juniperus przewalskii* Komarov
0	SBRE	*Sabina recurva*
1	SBSA	*Sabina saltuaria*
1	SBTI	*Sabina tibetica*
1	SBWA	*Sabina wallichiana*
	SASP	*Salix* L. willow
0	SAAC	*Salix acutifolia* Willd. pointed-leaved willow
1	SAAL	*Salix alba* L. white willow
0	SAAM	*Salix amygdalina* L. almond-leaved willow, peachleaf willow
0	SAAD	*Salix amygdaloides* Anderss. peachleaf willow
0	SAAR	*Salix arbusculoides* Anderss. littletree willow
0	SAAT	*Salix arctica* Pall. Arctic willow
0	SABA	*Salix babylonica* L. weeping willow
0	SACN	*Salix candida* Fluegge sage-leaf willow, silver willow
0	SACA	*Salix caprea* L. pussy willow, goat willow
0	SACR	*Salix caroliniana* Michx. Coastal Plain willow
0	SADI	*Salix discolor* Muhl. pussy willow, glaucous willow
0	SAEL	*Salix elaeagnos* Scop. hoary willow
0	SAEX	*Salix exigua* Nutt. sandbar willow
0	SAGL	*Salix glauca* L. grayleaf willow
		Salix interior Rowlee = *Salix exigua* Nutt.
0	SALA	*Salix lanata* L. Richardson's willow
0	SALS	*Salix lasiolepis* Benth. arroyo willow, white willow

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	SAMY	*Salix myrsinifolia* Salisb.
0	SAPH	*Salix phylicifolia* L. tea-leaf willow
0	SAPL	*Salix planifolia* Pursh sandbar willow, lakeshore willow, diamondleaf willow
0	SAPU	*Salix purpurea* L. purple willow, purple osier *Salix triandra* L. = *Salix amygdalina* L.
0	SAVI	*Salix viminalis* L. basket willow, common osier
0	SNAL	*Santalum album* L. sandalwood, santalin, chandal
0	SSAL	*Sassafras albinum* (Nutt.) Nees sassafras
1	SACO	*Saxegothaea conspicua* Lindl. Prince Albert's yew, manio de hojas cortas, manio hembra
0	SCTR	*Schleichera trijuga* Willd. ta-kro, kusum, kusamo
0	SCMI	*Schleronema micranthum* Ducke. cordeiro, scleronema
1	SESE	*Sequoia sempervirens* (D. Don) Endl. coast redwood
2	SEGI	*Sequoiadendron giganteum* (Lindl.) Buchholz giant sequoia
0	SHRO	*Shorea robusta* Gaertn.f. sal
0	SOAM	*Sorbus americana* Marsh. mountain ash
0	SOAR	*Sorbus aria* (L.) Crantz whitebeam
0	SOAU	*Sorbus aucuparia* L. mountain ash, rowan
1	SOTE	*Sorbus torminalis* (L.) Crantz chequer tree, wild service tree
0	SODU	*Sorocea duckei*
0	SWLA	*Swartzia laevicarpa* Amsh. saboarana
0	SWMA	*Swietenia mahagoni* Jacq. West Indies mahogany
0	TABA	*Tabebuia barbata* (E. Mey) Sandw. Igapo-tree
0	TMAP	*Tamarix aphylla* Lanza dur
0	TMCH	*Tamarix chinensis* Lour. tamarisk, salt cedar
0	TMJO	*Tamarix jordanis*
0	TPGU	*Tapirira guianensis* Aubl. tapirira, cedroi, jobo
0	TMXE	*Tasmannia xerophila*
0	TAAS	*Taxodium ascendens* Brong. pond cypress
2	TADI*	*Taxodium distichum* (L.) Rich. baldcypress
1	TABA	*Taxus baccata* L. common yew, English yew
1	TACU	*Taxus cuspidata* Sieb. & Zucc. Japanese yew

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
1	TEGR	*Tectona grandis* L. f. teak
0	TETO	*Terminalia tomentosa* W. & A. Indian laurel, taukkyan, sain
1	TEAR	*Tetraclinis articulata* (Vahl) Mast. Arar tree, African thuya
	THSP	*Thuja* L. thuja
2	THOC*	*Thuja occidentalis* L. northern white-cedar, American arborvitae
0	THOR	*Thuja orientalis* L. Chinese arborvitae, Oriental arborvitae
1	THPL*	*Thuja plicata* Donn ex D. Don western redcedar, giant arborvitae
	TISP	*Tilia* L. linden, lime tree
1	TIAM	*Tilia americana* L. American basswood
1	TICO	*Tilia cordata* Mill. littleleaf linden, winter linden, small-leaved lime
1	TIPL	*Tilia platyphyllos* Scop. broad-leaved linden, summer linden
0	TRSC	*Triplochiton schleroxylon* K. Schum. abachi, obeche, wawa, arere
0	TRCO	*Tristania conferta* R.Br. Queensland box tree
	TSSP	*Tsuga* Carr. hemlock
2	TSCA*	*Tsuga canadensis* (L.) Carr. eastern hemlock
1	TSCR*	*Tsuga caroliniana* Engelm. Carolina hemlock
0	TSDI	*Tsuga diversifolia* (Maxim.) Mast. Japanese hemlock
1	TSDU	*Tsuga dumosa* (D.Don) Eichl. East Himalayan hemlock
2	TSHE*	*Tsuga heterophylla* (Raf.) Sarg. western hemlock
2	TSME*	*Tsuga mertensiana* (Bong.) Carr. mountain hemlock
0	TSSI	*Tsuga sieboldii* Carr. southern japanese hemlock
	ULSP	*Ulmus* L. elm *Ulmus caprinifolia* G. Suckow = *Ulmus minor* Mill.
1	ULGL	*Ulmus glabra* Hudson Wych elm, Scots elm, mountain elm
1	ULLA	*Ulmus laevis* Pall. European white elm
1	ULMI	*Ulmus minor* Mill. smooth-leaved elm, field elm, common elm
0	ULPU	*Ulmus pumila* L. Siberian elm
1	ULRU	*Ulmus rubra* Muhl. slippery elm
	UNKN	Unknown
0	WERA	*Weinmannia racemosa* L.f. kamahi

Table 3. (cont.)

CDI	Code	Latin Name, Authority, and Common Name
0	WETR	*Weinmannia trichosperma* Cav. tineo, tenio, palo santo
1	WICE*	*Widdringtonia cedarbergensis* J.A. Marsh Clanwilliam cedar
0	ZISP	*Zizyphus spina-christi* Judas tree, Christ thorn
	ZYSP	*Zygophyllum* L.
0	ZYDU	*Zygophyllum dumosum* Boiss.

[1] *Pinus densata* actually refers to two separate pine species that overlap in west-central China, *Pinus tabulaeformis* (Chinese pine) in the northern region and *Pinus yunnanensis* (Yunnan pine) in the south (Mirov and Hasbrouck 1976).

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REPORT TO THE MEMBERSHIP

As a result of the election following the general membership meeting held on 18 May 1994 in connection with the International Tree-Ring Conference in Tucson, Arizona, the Tree-Ring Society has a new slate of officers as listed on the back cover of the *Bulletin*. The new President is David C. LeBlanc of the Department of Biology at Ball State University in Muncie, Indiana, USA. Lisa J. Graumlich and Jeffrey S. Dean of the Laboratory of Tree-Ring Research at The University of Arizona in Tucson were re-elected to the positions of Treasurer (Graumlich) and Secretary and Editor (Dean). Tree-Ring Society and Bulletin membership and subscription records, word processing, and mailing remain in the capable hands of Subscription Manager Jackie Mather of the Laboratory of Tree-Ring Research.

In view of the increasingly interdisciplinary and international character of dendrochronology in general and the Society in particular, the *Tree-Ring Bulletin* Advisory Council has been reconstituted and expanded. Dieter Eckstein and Jaan Terasmae have left the Council after twenty years of dedicated service to the journal and the Society, while Zdzislaw Bednarz of the Polish Academy of Agriculture and Andre V. Munaut of the Université Catholique de Louvain in Louvain-la-Neuve, Belgium, remain on the Council. We owe all these individuals a debt of gratitude for their many contributions. The following new members have been added to the Editorial Advisory Council: Niels Bonde of the National Museum of Denmark in Copenhagen, José A. Boninsegna of the Instituto Argentino de Nivología y Glaciología in Mendoza, Won-Kyu Park of Chungbuk National University in Cheongju, Republic of Korea, Lucien Tessier of the Mediterranean Institute of Ecology and Paleoecology in Marseille, France, Eugene Vaganov of the Siberian Branch of the Russian Academy of Science in Krasnoyarsk, and Tomasz Wazny of the Academy of Fine Arts in Warsaw, Poland.

Recent advances in rapid, worldwide communication have substantially diminished the need for a Society newsletter. Society members and other dendrochronologists can keep abreast of current developments in the field far faster and more easily through facsimile transmission and electronic mail than through the medium of an annual newsletter. Therefore, the *Tree-Ring Society Newsletter* has been discontinued. Jon R. Pilcher and Michael G. L. Baillie of the Queen's University in Belfast, Northern Ireland, deserve the thanks of all Society members for ably serving as *Newsletter* editors and for facilitating communication among tree-ring scientists around the world.

Jeffrey S. Dean
Secretary and Editor
Tree-Ring Society

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