

Soil Conservation Service Tests of *Eucalyptus* Species for Windbreaks¹

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The Soil Conservation Service (SCS) is an agency of the U. S. Department of Agriculture. Our national plant testing program includes many grass and tree species and its goal is selecting adapted cultivars for soil erosion control. The SCS operates 23 Plant Materials Centers (PMC) nationwide, and 2 of the Centers located at Tucson, Arizona and Lockeford, California are involved in testing trees for windbreaks in the southwest. We are looking for widely adapted cultivars of several *Eucalyptus* species for use as windbreaks throughout the Mediterranean climate area of California and the adjoining warm winter area of Arizona. Our program will consist of initial testing, evaluation, and advanced testing. We expect to be involved with growing and evaluating *Eucalyptus* for the next 20 years.

TEST CONDITIONS

Climate

The climatic means and extremes at Lockeford and Tucson are similar. The minimum temperature reached on an average of once each year is -8° to -7°C (18° to 20°F) and lasts less than 6 hours. The highest temperatures expected in the summer are 42° to 44°C (108° to 112°F), slightly lower in Tucson. For Lockeford, the long term average annual rainfall is about 430mm (17 inches), nearly all falling in the 6 months of winter.³ Tucson is dryer, with an average of 280mm (11 inches), but the rain is more evenly distributed over the year (Briggs 1982).

Soils

The soils at Tucson are Grabe loam and Comoro

¹Presented at the Workshop on *Eucalyptus* in California, June 14-16, 1983, Sacramento, California.

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Abstract: The Soil Conservation Service is in the early stages of testing many species of *Eucalyptus* for windbreaks. Over 260 different species have been collected. The pre-planting selection criteria and process is described as well as the test conditions and procedures. Some sources of information on the use of the *Eucalyptus* may be misleading through overgeneralization. Early results support the need for greater communication and testing of a wide variety of species and provenances in California.

fine sandy loam more than 1.5m (60 inches) deep. They are moderately alkaline and somewhat calcareous (Richardson 1979). The soils at Lockeford are deep Honcut loam and Columbia fine sandy loam. They are neither alkaline nor calcareous.⁴

Management Practices

The management practices at Tucson and Lockeford are also similar. Because we are testing these trees for use as part of a 2 or 3 species windbreak, we will manage them as we would expect the landowner to manage them. The *Eucalyptus* are planted in the spring and given deep irrigations as needed during the first summer. Supplemental irrigations in following years will be applied as necessary. We feel the increased survival and vigor of the trees justifies the investment of water and time to provide irrigation for many years.

Weed control is essential and is performed chemically and mechanically as long as needed. The trees are usually able to shade out weeds and/or withstand the competition from them after 2 years.

The management program for the nursery also includes removing broken limbs and downed or severely damaged trees. Any pattern that may be found in the breakage of limbs and trees is valuable data to record and can eliminate from further testing any species that are excessively prone to wind-throw and damage.

Design and Evaluation

At Lockeford, the plantings (nurseries) are made in blocks, not oriented or designed as windbreaks. This is primarily to save space and to facilitate management within our normal field divisions. The nurseries contain 36 accessions of *Eucalyptus* (in addition to many accessions of other genera) planted in 1979, 1980, and 1981.

At Tucson, in order to include the largest possible number of different species in the tests,

⁴Soil survey records on file, Lockeford Plant Materials Center, Lockeford, Calif.

a decision was made to include those accessions where there were only 1, 2, or 3 specimens available after propagation. This causes problems in measuring the significance of observations based on so few individuals. The normal full complement at Tucson is 4 and at Lockeford is 6. At Lockeford, no accessions were included which had fewer than 6 specimens at planting time.

The trees are planted in rows of 5 accessions, each represented by 6 specimens. The spacing between the trees is 3m (10 feet); the spacing between rows is 6m (20 feet). This spacing represents a compromise between proper spacing for windbreaks and wider spacing to allow the natural shape and size to be expressed. The different accessions are evaluated throughout the year. The trees are measured for height and width (canopy cover) at the end of each growing season. The accessions are also rated for stem abundance and distribution and foliage abundance and distribution in comparison to a known standard. The standard we are using for our Eucalypts is Dwarf blue gum, (Eucalyptus globulus var. compacta Labill.), which has been in the California landscape trade for many years. As a common landscape tree, it has been planted widely, and its performance is well known. The trees are also rated for their resistance to disease, insects, cold, heat, and drought. A rating is made twice a year of the accession's vigor and of its suitability. Both of these ratings are somewhat subjective, but both are closely related to the standard of comparison. As a measure of vigor, Tucson has used the height of each year's growth expressed as a percentage of the mature height expected. All of these measurements and ratings (and many more facts) are done on standard forms. The data is then entered into the nationwide data bank SCS maintains for plant material evaluations.

SPECIES SELECTION

When we assemble a collection, it is for a particular need; in this case, windbreaks. The selection process used by the SCS is to explore existing information sources to select the 2 or 3 most promising species. We then conduct ecotype testing within that species. Unfortunately, there are many species of Eucalyptus and a small number of references and information sources for their adaptations. Because of this, we decided to test a large number of Eucalyptus species for general characteristics. From these, we would select a few species on which to conduct provenance or ecotype testing.

Collection

The group of species from which we can make our selection has been strongly affected by our source of seed. We requested packets of seed from Australia through our National Plant Materials Center at Beltsville, Maryland. The Australians sent us many small packets from the National

Botanic Garden in Canberra. Most of the packets are marked with some collection location data. The amount of seed in a packet (usually less than 1 gram) is seldom enough for more than a single test. The Australians have compensated for this by sending a large number of species. We have received over 300 accessions from Australia and about 50 from domestic sources. Many of these 50 were probably also collected in Australia. These 350 accessions represent 263 species. We will select from these to compile the list of species and accessions for our future plantings. The next nursery will be propagated soon and will be planted in the early spring of 1984. It will consist of approximately 200 accessions.

To guide us in our selection, we are using information from the first small nurseries we planted in 1979, 1980 and 1981 combined with information from the Tucson PMC. Several reference books we have located contain information on adaptations, requirements, and physical properties for a large number of species (Jacobs 1981). These books also cover a wide range of conditions. Some data are on important or restrictive conditions that we cannot test at Lockeford, such as shallow soils and saline or calcareous soil.

Selection Criteria

Species that are adapted to a wide range of soils and climatic conditions are most appropriate to our needs. More importantly, when we make a selection, it is primarily based on those characteristics that we feel are most relevant to windbreaks in California: growth habit, mature size, drought tolerance and frost tolerance.

Growth Habit

The preferred growth habit is a tree with a columnar form and one to several trunks. The foliage and small limbs should be persistent and relatively dense near the ground for several years. These two basic requirements can cause conflicts with other management systems. The multiple trunks and the persistent foliage near the ground would be negative factors in a woodlot management system. The low foliage would also contribute to the fire hazard that is a concern with the Eucalypts.

Deciduous bark, leaves and branches can create a problem when Eucalyptus are planted near row crops. Selection of a species for agricultural windbreaks is limited by these characters not because they affect windbreak efficiency, but because they affect the acceptance of a species by users.

Mature Size

For our needs and our tests, the mature size should be between 15m (50 feet) and 40m (130 feet). This large size is preferred for two reasons.

First, the large trees have a very rapid growth rate when young, (expressed as a percent of mature height achieved each year) and will thus achieve a suitable height for windbreaks (8-12m 1.26-40 feet) in a relatively few years. Second, the major application for these trees is the protection of agricultural land and operations. The economics of farm management dictate that windbreak rows be tall and widely separated to minimize the land consumed and maximize the size of the fields between windbreaks.

Drought and Frost

Drought tolerance and frost tolerance are the two most important factors used by Eucalyptus growers in species selection.⁵ Both are somewhat subjective and are affected by local conditions. The data the growers are relying on could be misleading.

Their information may be based on a vigorous local planting. A species' sensitivity may be masked by an unknown irrigation source or a more sheltered position during frost periods. To obtain accurate frost sensitivity or tolerance data, we maintain a recording weather station approximately 300m (1000 feet) from our plantings.

We are trying to select species that are drought tolerant, but we are not subjecting our plants to drought at this time for two reasons. First, we propose and presume that windbreaks will generally be irrigated. Second, we are unable to subject the plants to a true drought due to a fairly shallow moisture level from the nearby Mokelumne river.

In the future, advanced testing will involve several different sites in the various climatic areas of California where more extreme conditions will be encountered.

Selection Complications

Another source of errors in suitability information is the misidentification of species that survive or fail. Only training, care, and good reference authorities can solve this problem.

It is also very difficult to interpret the existing climatic data from foreign sources. There are always questions of which data most accurately describe the critical factors. Are they mean maximums and minimums of temperature or are they the extremes?; is it the amount or the distribution of rainfall for the year?

⁵Personal communication with Sherman Finch, State Forester, Soil Conservation Service, Davis, Calif.

Other questions remain if the information is incomplete or misleading through generalization. Does the dry season coincide with the hot season? Are the frost periods of long duration or of only a few hours? One example of such misleading data comes from a European publication. In describing the climate of California relative to the needs of (E. globulus Labill.), San Francisco is used as the reference climatic station for the state (Jacobs 1981).

RESULTS

One result of our test to date is the observation of two conditions or patterns that exist in some of the Eucalypts.

The first is a variation in the limb attachment morphology between species. The process of shedding small branches in the Eucalypts has been praised by timber and landscape users for producing clear trunks. The process we observed affects the major limbs or secondary trunks in some species, e.g. (E. grandis W. Hill ex Maiden). As a limb puts on its second years' growth, a crescent-shaped area of bark is formed just above where the limb meets the trunk. This crescent extends into the joint area, filling it and forming a plane of weakness directly across the area where tension forces supporting the limb are greatest. The wood in this area also seems to be weak, separating along a conical surface, with very little shattering or breaking. In those species not showing this limb characteristic, e.g. (E. globulus Labill.), the joint area is filled by trunk and limb wood instead of bark.

The second pattern is similar. In some species, e.g. (E. smithii R. T. Bak.; E. macarthurii H. Deane & Maiden), the trunk will separate from the roots. After a tree falls during a strong wind, we see it has broken cleanly near or slightly below ground level. The broken end of the trunk is a convex surface. This surface consists of several planar areas each representing the attachment point for a root. The wood in these areas is not shattered and broken. It appears to be compressed and fibrous. The plane the fibers are in is perpendicular to the centerline of the trunk and roots. A similar surface is on the ends of the roots. There is very little broken wood and virtually no disturbance of the ground where roots have started to pull loose. The area involved appears to be at or near the point where "root" tissue meets "stem" tissue. This physiological point may be a contributing factor in the location of the failure point.

Further observation of these and other species is needed to see if a predictable pattern exists.

Some other preliminary results are variations and correlations between our test plants and the literature.

Manna gum, (*E. viminalis* Labill.), has exhibited enough differences between our two accessions that a provenance trial should be conducted under California conditions. There are many provenances recognized in Australia (Jacobs 1981). Both accessions have reached 10m (32 ft.) in 4 years.

Maiden's gum, (*E. maidenii* F. J. Muell.), is now called (*E. globulus* Labill. ssp. *maidenii* Kirkp.). This is our outstanding performer. Starting from seed, it has reached a height of 12m (40 ft.) in 4 years. In Australia, the crown widens as the tree matures (Forestry Commission 1980). This may require a rotation management system to maintain the proper shape.

Sugar gum, (*E. cladocalyx* F. J. Muell.), shows good vigor and growth rate, but it has a bare trunk and an open crown. Sugar gum has been widely used for windbreaks in Australia (Jacobs 1981). Multiple row windbreaks are planted, and every few years one row is cut for wood or poles. The coppice shoots from the stumps fill in the openings between the remaining trunks.

Karri gum, (*E. diversicolor* F. J. Muell.), is described as a tall, single trunk tree that is excellent for timber (Jacobs 1981). Our accession has suffered very minor visible frost damage, but as a result, has become a very irregular shrub.

Camden wollybutt, (*E. macarthurii* H. Deane & Maiden), is considered a good shelterbelt tree because of its form and lack of windthrow. In our accession, 5 of the 6 specimens have broken at the base in moderate winds.

Dwarf blue gum, (*E. globulus* var. *compacta* Labill.), has demonstrated excellent potential for windbreaks. Ours have grown to 5 m (16 ft.) tall in 4 years and are very dense. It may be too dense for the first 3 years, letting very little air filter through. Approximately 5 percent of the

plants revert spontaneously to the tall form. This leaves gaps in the row. This variety may make an excellent 2-row windbreak with one of the taller, more open species.

CONCLUSIONS

It is too early in our testing program for us to have a recommended variety or even a species of *Eucalyptus* for growers and researchers. There are some things we do have. We have seed samples of a large number of species for our future work. As a government agency, we can work through foreign research groups to get more seeds and test results. We also have the facilities of the Plant Materials Center, our testing and evaluation system, and our nationwide data base, to help us develop and distribute information on *Eucalyptus*.

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