

Creating a Database on *Eucalyptus* for California¹

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Increasing interest in rural woodlots for fuelwood and low-maintenance ornamental plants has sparked a resurgence in eucalyptus plantings in California. Those concerned with planting, propagating and maintaining trees are turning to public and private land use advisors, e.g. University of California Cooperative Extension, Calif. Department of Forestry and U.S. Soil Conservation Service, for detailed information on the many eucalyptus species that have been introduced into the state. Despite the fact that eucalyptus have been planted in California for over a century, up-to-date, reliable information on the growth, yield and suitability for different uses of individual species is not readily available. While a number of past and present species trials have been performed, the results of this work have not been collected systematically into a form readily useable by those called upon to provide information to the public.

Interest in eucalyptus planting as well as organized field trials are likely to continue in future. Therefore, a coordinated effort to collect and disseminate information about eucalyptus species in California would benefit a wide variety of people concerned with the genus. This information would be useful to public and private agencies that advise landowners on land use decisions, nurserymen that propagate the trees, landscapers that incorporate eucalyptus into the urban landscape for amenity and shade, and ultimately the individual citizen interested in planting the trees.

INITIAL SPECIES SURVEY

In 1982, a compilation of information was begun on a number of eucalyptus species that have been planted or proposed for trial in California. The purpose was to collect the following information: (1) results of past and present planting trials in the state; (2) data on the typical growth, climate and soils of the native range in Australia; and (3) other relevant information on

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Abstract: While public agencies, nurserymen and landscapers are receiving more inquiries about individual eucalyptus species for California plantings, little information is readily available to them on the potential usefulness or adaptability of these species. A survey of eucalyptus species was undertaken to collect information on their performance both in California trials, their native range and other overseas countries. It is proposed that this survey form the basis of a printed handbook and computer database on eucalyptus in California as an on-going interagency project.

the performance of individual eucalyptus species when planted as exotics (introduced species). This species survey was intended primarily as a useful reference for public land use advisory agencies, foresters, farm managers, nurserymen, landscapers and researchers. It was not intended as a popular guide for the average landowner, except those cooperating in research trials.

The species survey was initiated under the direction of Dr. Andrew Leiser, Dept. of Environmental Horticulture, University of California, Davis. Species chosen for study were taken in part from earlier unpublished work by Dr. Leiser on drought resisting plants (Leiser, 1983) and in part from a review of the literature on other species exhibiting some degree of frost and/or drought tolerance. Over 100 species were initially chosen for study.

Using standardized data collection sheets, information was first compiled on the growth, climate, soils, wood and uses of each species in its native range in Australia, and the comparative success and productivity of those species when planted commercially overseas. After this initial review, several species not adaptable to cultivation as exotics or suitable only as ornamentals were eliminated from further consideration.

Information on the remaining 79 species was summarized in a standard format. This first draft was then sent to a number of reviewers in California with requests for information on past and present planting trials, uses and other practical experience with their cultivation in the state. The literature was also searched for published reports on past trial and commercial plantings of eucalyptus species. Only those species for which well documented information on trial plantings is available are included in the final selection. The particular selection of species covered in the published report (Merwin, 1983) does not mean to imply that other species have not been tested or would not also be potentially successful if introduced into California.

FORMAT AND CONTENT OF SPECIES SURVEY

A standardized format was used for the compi-

GROWTH IN NATIVE RANGE: Tree usually 80-120 ft. (to 150 ft.) tall with an often crooked trunk 3-7 ft. in diameter and a thin crown. Vigorous coppicer. Fairly fire resistant. Fast growing.

NATIVE RANGE: All states except TAS, along year-round and seasonal watercourses, esp. the Murray-Darling River system, at 100-750 (to 1800) ft. elevation. Latitudinal range 15.5°-38°S.

CLIMATE OF NATIVE RANGE: Annual rainfall mainly 10-25 in. (to 40 in.). Relies on seasonal flooding or high water table in areas of 10-15 in. rainfall. Hot dry summers with temps. to 115°F. Lowest temp. 23°F. (-5°C). Frosts 5-20.

CLIMATIC TOLERANCES: Drought. Reportedly tolerates 20-26°F as exotic.

SOILS OF NATIVE RANGE: Best on deep silty soils, clay soils and podsols. Ecotypes grow on poor soils, e.g. poorly drained flats wet for several months that don't completely dry out, acid sands, alkaline swampy clays. Becomes chlorotic on calcareous soils.

SOIL-RELATED TOLERANCES: Flooding. Heavy clay soils. Salinity (selected provenances). Coastal salt spray.

WOOD: Red, interlocked or wavy grain, gum veins or pockets common, hard, durable, termite resistant, density 980 kg/m³. May be difficult to split.

USES: Fuelwood, post/poles, shelter, amenity, honey, particle board, sleepers.

PROVENANCE: At least 8 distinct groups of provenances identified, each with significant differences in drought or frost resistance, growth rate and wood properties. 6845 Lake Albacutya, VIC proven consistently superior in tests throughout Mediterranean-type climates (FAO).

SUCCESS OUTSIDE AUSTRALIA: Important commercial species in Spain, Morocco, Israel, Turkey and other Mediterranean countries.

PRODUCTIVITY IN PLANTATIONS: Good sites: aver. 2.2-3.3 cords/ac/yr. Poor sites: aver. 0.2-1.1 cords/ac/yr (FAO).

GROWTH IN CALIFORNIA:

Chapman, 1982: "Spanish" selection from Florida Div. of Forestry gave best growth rate and survival of all species tested over a wide variety of Calif. sites.

Davis, 1978: Outstanding results. Species most tolerant of wide range of unfavorable soil and climatic conditions, e.g. salinity, flooding, poor drainage and drought. Survived 1972 freeze (15-25°F). Upright narrow growth form observed.

Ledig, 1983: In test of 23 provenances at Concord N.W.S. and other sites, Lake Albacutya, VIC was approximately 161 percent better than average for all provenances. This and other superior provenances all came from Murray-Darling River drainage [sic] in VIC and NSW.

Heavilin, 1978: Killed by frost at Redwood Exp. For.

King and Krugman, 1980: One of the best surviving, fastest growing spp. at Concord N.W.S.

McClatchie, 1902: Grows well on coast and in foothills, interior valleys and deserts. Fast growing. Open grown trees often very forked.

Metcalf, 1924: MAI of 26 plantations, average age 9 years, was 1.2 cords/ac/yr (range 0.4-2.8). Grows better in interior valleys and So. Calif. than along the coast.

Metcalf, 1967: Survives annual flooding along Sacramento River. Grows well in Imperial Valley with irrigation. Has survived temps. lower than 23°F in Sacramento Valley but tops killed back by 1932 freeze. Tree at Watson Arb. grew 14 ft. with 1.6 in. dbh in 2 yrs.

Sachs and Low, 1983: Two year old coppice growth at Davis from 5000 trees/ac with flood irrigation (fertilizer at planting only) yielded 16.81 ODT/ac/yr (aver. 2.0 ODT/cord). Yield for hybrid with E. rudis in same trial was 16.94 ODT/ac/yr.

PLANTING PROSPECTS: Excellent with careful provenance selection.

PAGATION: Adaptable to containerized nursery production but liable to be quickly overgrown. Light essential for full germination.

OTHER: Hybridizes with E. botryoides to form E. X trabuttii, and also with E. rudis.

REFERENCES: Boland, et. al., 1980; Coate; FAO, p. 369; Hall, p. 100; Hemstreet.

Figure 1--Example of standardized format for compilation of species information.

lation of species information, an example of which appears in Figure 1. Species nomenclature conforms to the most recent classification of the genus (Blakely, 1965). The "Blakely Number" assigned to each species or subspecies is listed after the Latin binomial.

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Native Range

The first few headings describe the common growth form, geographic and topographic locations, average climatic conditions, soil factors, wood characteristics, main farm and/or commercial uses, latitudinal range and provenances (if any) for each species in its native habitat in Australia.

Under the heading "Growth in. Native Range," the range of observed heights for each species, as a tree or mallee, are given along with crown characteristics and the diameter, form and length relative to total tree height of the trunk. Observations from the native range are also included on relative growth rate, coppicing ability, fire sensitivity and other details.

Australian states included in the native range of each species appear under "Native Range." Topographical distribution, elevations, and latitudinal range are also listed here. The more widespread the geographic and topographic distribution of a species, the more diverse the local ecotypes are likely to be. Thus careful selection of provenance for seed collection becomes more important (F.A.O., 1979).

Average climatic data for the native habitat is listed under "Climate of Native Range." Annual amount and seasonal distribution of precipitation is listed along with the relative length and severity of the dry season. Rainfall and dry season length are indicative of the relative tolerance of low moisture and high summer temperature conditions that the species may exhibit as an exotic. Lowest recorded temperatures in the native range and the frequency of frost are also given. While this information may indicate the relative cold hardiness of a species, widely distributed species will exhibit high variability in this trait. In some cases, species may tolerate lower temperatures when planted as exotics than in the native range (F.A.O., 1979).

Edaphic factors for each species are listed under "Soils of Native Range." Listed first are the preferred types of soils on which best growth occurs, then those soil types on which the species also occurs but where its development is not optimum. Among the characteristics noted of these soils are texture, structure, relative depth and drainage, pH, presence of salts or limestone and overall quality.

Environmental Tolerances

Data on growth form, climate and soils recorded under the headings described above is representative for each species in their native range and is intended as a benchmark for each species.

Their growth and environmental tolerances when planted as exotics, e.g. in California, may be different than that found in the native range. Thus information listed under the headings "Climatic- and Soil-Related Tolerances" summarizes observations from both the native habitat and plantings outside Australia. Comparative tolerance to the most important limiting factors, e.g. drought, cold, flooding, salinity, etc., are listed under these headings.

For the introduction of these species into California, cold tolerance is generally a more important limiting factor than drought (since plantings are usually at least established with irrigation), thus determining their adaptability to different geographic regions of the state (Hemstreet, 1983). However, drought tolerance is also an important factor since many eucalyptus species are used in low-water, low maintenance situations specifically because of their resistance to drought. Soil factors may be less important in determining the suitability of individual species to exotic plantings, except in extreme situations such as heavy clays, infertile sands, shallow or poorly drained soils, and highly alkaline or saline soils.

Characteristics described of the wood of each species as harvested under native range conditions include color, grain, hardness, structural strength, durability (in contact with soil as a fencepost), ease of splitting, and density. Traditional or commercial uses for each species and its products in Australia are recorded under "Uses." Feasible uses for the trees when planted as introduced species in California may be different from those listed.

Provenance

Seed provenances that have been identified, collected and tested are listed under "Provenance." In some cases where the geographic and topographic distribution of a species is wide, recommendations for provenance testing or careful selections are noted. Due to the inherent seedling variability of these wide ranging species, proper selection of seed provenance can be crucial to the success of a trial or commercial planting (F.A.O., 1979). In prior evaluations of overseas trials of these species, the possibility should be considered that the provenance of the seedlings tested was mismatched to the test site or was atypical of the species. Current provenance trials in California and other countries are also noted under this heading.

Overseas Plantings

Then follow several sections related to species performance as exotics, i.e. successful plantings outside Australia, yield in intensive plantations, and growth in different areas of California. Growth rates and wood yields from intensively-managed, overseas industrial plantations, under "Productivity in Plantations," are reported with a word of caution that the yield

that can reasonably be expected from stands of any species is strongly dependent on site quality and level of management (Standiford, 1983). Mention of successful commercial overseas plantings under the heading "Success Outside Australia" is restricted to only other American states (e.g. Florida, Hawaii) and those countries that contain areas climatically similar to California (i.e. Mediterranean type), even though there may be other nations where a particular species has been planted.

Under the heading "Growth in California," published reports on field trials and commercial plantings in the state are summarized. Personal communications with individual researchers, foresters, nurserymen, etc. are also included here. When comparing the performance of a species in the various test plantings reported, consideration should be given to the existence of factors that affect seedling performance, e.g. differences in planting method, irrigation, spacing, provenance, etc. While efforts were made to report on as many plantings of eucalyptus in California as possible, there are obviously many others that are either not well documented or were unavailable to the author.

Propagation

The section entitled "Planting Prospects" is a consensus of opinion from the references cited on the relative usefulness of a particular species and its adaptability to different regions of the state. Species are rated under "Propagation" for their relative adaptability to containerized production in commercial nurseries based on information supplied by two experienced California nurserymen (Coate, 1983; Solomone, 1983). While most eucalyptus species are adaptable to containerized propagation, fast growth during the early seedling stages makes them susceptible to quickly becoming overgrown and rootbound, thus timing is more critical than with slower-growing species (Coate, 1983). Finally, additional information on hybrids, varieties, cultivars, seedling variability, disease and pest resistance, storm damage, pruning needs, etc. are listed when available under "Other."

PROPOSED HANDBOOK AND DATABASE

The information contained in the written survey of eucalyptus species described above lends itself to adaptation for an electronic database accessible by microcomputer. This database would be designed for use in conjunction with a printed, looseleaf handbook on eucalyptus, published as an on-going interagency project. It is proposed that this initial survey form the basis for the creation of such a handbook and database.

Most of the inquiries about eucalyptus received by land use advisors, nurserymen and landscapers will likely be to identify those species adaptable to a particular set of climatic and edaphic conditions, and useful for particular purposes. With

a computerized database, this information can be retrieved with relative speed and ease compared to manual searching of printed documents. Several database management programs are commercially available that could be used to cross-index succinct categories of information, or "fields," for individual species, such as growth rate, drought tolerance and uses. Thus, for example, one could use several "keywords" each relating to a different field to ask for a list of species adaptable to moderately cold winters and summer drought on heavy clay soils that are useful for windbreaks or firewood. Once such a list was retrieved, users could then refer to the printed handbook for a current, detailed description of each species, listing such information as seed provenances, commercial availability of seedlings and research contacts.

Creating the Database and Handbook

The primary task of creating the database will be to define the individual characteristics of each species that will be cross-referenced by computer, either in relative or absolute terms. Once the necessary software is modified and the original database is completed, periodic updating of species information could be done simply by issuing supplemental pages for the handbook. Researchers and others involved in field evaluations could report their results as available to one agency whose responsibility would be to update the handbook with this new information. Such updates would probably only be necessary one or two times per year. The handbook could also be expanded to include narratives on topics such as propagation, establishment and management.

Online access to the database could be arranged through local offices of the public agencies involved using any compatible terminal or microcomputer. This is facilitated by the fact that more of the public agencies receiving requests for eucalyptus information will soon have microcomputer systems in their local offices, e.g. University of California Cooperative Extension and U.S. Soil Conservation Service (Finch, 1983; Standiford, 1983). Those offices without such equipment could request searches to be done at a central office and the results printed out and mailed to them. Alternatively, the database could be accessed from remote terminals to a central computer via appropriate telecommunications equipment.

Funding

The bulk of the funding for this project would be needed in the first year, since the major tasks will be to create the initial database and printed handbook. The database can then be reproduced on inexpensive "floppy diskettes" and copies distributed to local offices. From then on, the relatively low cost of periodic updates and distribution could be covered by sales of the handbook and database or fees charged to the cooperating agencies or the individual

end users. It has been suggested that the University of California, through the U.C. Davis Dept. of Environmental Horticulture and/or U.C. Berkeley Extension Forester's office, be the lead agency for the database if foundation funding can be secured for the project. Since its purpose will be to benefit public land use advisory agencies, nurserymen, landscapers, etc. in California, these groups must necessarily be involved in determining the format and content of the handbook and database that best serves their needs.

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