# DRYING OF MAJOR CYPRESS SPECIES GROWN IN NEW ZEALAND

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ABSTRACT

Old shelterbelt-grown **Cupressus macrocarpa** Hartw. sawn timber showed excessive collapse and internal checking after kiln drying. Careful air drying is recommended followed by mild kiln or dehumidification drying. Plantation-grown **C. macrocarpa** and **C. lusitanica** Mill. performed better than over-mature shelterbelt-grown **C. macrocarpa** and both may be kiln dried from green if temperatures are kept below 40°–45°C for a substantial portion of the drying cycle. Otherwise, air drying followed by kiln drying is recommended.

**Chamaecyparis lawsoniana** (A. Murr.) Parl. sawn timber was kiln dried from green without difficulty and showed low distortion levels in drying. The hybrid × **Cupressocyparis leylandii** (Jacks. et Dall.) Dall. had similar drying characteristics to **C. lusitanica**.

**Keywords:** air drying; dehumidification drying; kiln drying; low-temperature drying; moisture content; shrinkage; checking; shelterbelt material; **Chamaecyparis lawsoniana**; × **Cupressocyparis leylandii**; **Cupressus lusitanica**; **Cupressus macrocarpa**.

## INTRODUCTION

The New Zealand Forest Service Exotic Special Purpose Timber Species Policy (1981) placed increased emphasis on the establishment and management of exotic species other than *Pinus radiata* D. Don. Two cypress species were recommended as warranting increased planting – *Cupressus macrocarpa* and *C. lusitanica.*

The timber of other cypresses is regarded as similar to the above species. *Chamaecyparis lawsoniana* has been widely planted in New Zealand, mainly in shelterbelts, and there is interest in growing hybrids such as × *Cupressocyparis leylandii.*

The Policy anticipates that cypress timber will be used for exterior joinery, weatherboards, boatbuilding, panelling, and decorative veneers – the first four uses all necessitate careful drying. Limited commercial experience had shown that the wood of several cypress species was difficult to dry and so drying studies were initiated with a view to facilitating improvements in commercial drying procedures.

## SPECIES AND METHODS

Typical values for physical properties of the species covered in this report are summarised in Table 1. All of them have medium to low density and low shrinkage, with dry heartwood and wet sapwood.

TABLE 1—Typical values for physical properties of cypress species grown in New Zealand

| Species | Green moisture content (%) | Density | | Shrinkage green to 12% m.c. | |
|---|---|---|---|---|---|
| | | Air dry ($kg/m^3$) | Basic ($kg/m^3$) | Tangential (%) | Radial (%) |
| **C. macrocarpa** | | | | | |
| Heartwood | 65 | 475 | 405 | 3.3 | 1.6 |
| Sapwood | 145 | | | | |
| **C. lusitanica** | | | | | |
| Heartwood | 75 | 460 | 385 | 2.6 | 1.4 |
| Sapwood | 150 | | | | |
| **Ch. lawsoniana** | | | | | |
| Heartwood | 65 | 480 | 400 | 3.6 | 2.2 |
| Sapwood | 150 | | | | |
| **Cu. leylandii** | | | | | |
| Heartwood | 60 | 495 | 415 | 3.2 | 1.4 |

### Cupressus macrocarpa

Of all the cypress species, greatest interest in New Zealand has been shown in *C. macrocarpa.* In its native Monterey it grows on rocky sea cliffs and has developed a high resistance to salt spray. In this country the species tolerates a wide range of climates, being moderately resistant to frost and tolerant of sea spray.

Planting of *C. macrocarpa* in New Zealand commenced in the 1860s and to date the majority of planting has been in small woodlots and shelterbelts. The largest plantation areas are in the Auckland, Wellington, and Canterbury Conservancies. Weston (1957) estimated that the annual planting rate in the 1950s was 100–200 acres (40–80 ha), mainly in shelterbelts. Under the current policy the annual planting target for the cypress species is 670 ha, but this target has not been met. The general tree form of the existing *C. macrocarpa* resource is not good, particularly in shelterbelts, with malformed stems and heavy persistent branching being the norm. Severe stem fluting is also common.

In 1983, 22 000 $m^3$ of *C. macrocarpa* sawn timber was produced in New Zealand (New Zealand Forest Service 1984), thereby making it the most important exotic softwood after the pines and Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), and more important than any indigenous hardwood species. *Cupressus macrocarpa* timber is accepted in the trade for its fine even texture, its attractive appearance, and its moderate natural durability. It is frequently compared to kauri (*Agathis australis*

D. Don) Lindl.) and most emphasis is now given to its use in boatbuilding, weatherboards, and exterior joinery. It is also considered a good general-purpose building timber.

Logs can be processed as for *P. radiata* but drying presents problems, with warp, collapse, and internal checking causing substantial degrade. Considerable attention has been paid to developing techniques for drying *C. macrocarpa* in recent years.

Five drying studies have been carried out at intervals by the Forest Research Institute, three on material from open-grown shelterbelts and two on plantation material from Whakarewarewa State Forest Park.

In the first study 25-mm sawn boards from the Waikato area were kiln dried. Schedules used ranged from 75°C dry bulb/65°C wet bulb (the schedule generally used for *P. radiata* boards) down to a mild schedule of 54.5°C dry bulb/49°C wet bulb (Table 2).

TABLE 2—Kiln schedules for 150 × 25-mm **Cupressus macrocarpa** from shelterbelt and plantation material

| Charge | Dry bulb temperature (°C) | Wet bulb temperature (°C) | Relative humidity (%) |
|---|---|---|---|
| **Shelterbelt material** (Study 1) | | | |
| 1 | 75.0 | 65.0 | 63 |
| 2 | 65.5 | 54.5 | 57 |
| 3 | 60.0 | 54.5 | 75 |
| 4 | 54.5 | 49.0 | 74 |
| **Plantation-grown material** (Study 3) | | | |
| 1 | 32.2 | 26.6 | 65 |
| 2 | 37.8 | 32.2 | 68 |
| 3 | 43.3 | 37.7 | 70 |
| 4 | 48.9 | 43.3 | 72 |
| 5 | 54.4 | 48.8 | 73 |
| 6 | 60.0 | 54.4 | 75 |
| 7 | 65.6 | 60.0 | 76 |
| 8 | 65.6 | 62.8 | 84 |

The second study involved air, forced air, and kiln drying of matched samples of both board and framing sizes after boron diffusion. The material was obtained from a 28-year-old shelterbelt growing in Rotorua. Air drying was in a small stack outside under a simple roof. Forced air drying was in a commercial heated unit at Waipa Sawmill. For the first 4 days the dryer was unheated; the temperature was then allowed to rise slowly to 30°C whilst the relative humidity fell to as low as 30%, although generally about 50%. The kiln drying was in an experimental kiln at the Institute according to the schedules in Table 3.

In order to clarify the effects of temperature in kiln drying a series of matched 150 × 25-mm samples from 31-year-old logs from Whakarewarewa Forest were dried on a range of schedules which had similar relative humidities but different temperatures (Table 2).

TABLE 3—Kiln schedules for 150 × 25-mm and 100 × 50-mm **Cupressus macrocarpa** (Study 2)

| Condition | Mean moisture content (%) | Dry bulb temperature (°C) | Wet bulb temperature (°C) |
|---|---|---|---|
| From green | Green | 52.0 | 40.5 |
| | 25 | 54.5 | 49.0 |
| | 16 | 60.0 | 52.0 |
| | Conditioning | 65.5 | 65.5 |
| After air drying | 30 | 52.0 | 40.5 |
| | 20 | 54.5 | 49.0 |
| | 15 | 60.0 | 52.0 |
| | Conditioning | 65.5 | 65.5 |

As the third study illustrated the critical role of temperature in drying, the fourth study compared air drying and low-temperature drying with kiln drying. For this study matched samples were either air dried, low-temperature dried at 38°C, or kiln dried either according to the schedule recommended for silver beech (*Nothofagus menziesii* (Hook. f.) Oerst.), which has an initial temperature of 54°C rising to 66.5°C (Kininmonth & Williams 1974), or at 71°/60°C throughout.

A fifth and final drying study was initiated to determine whether dehumidifiers could successfully kiln dry *C. macrocarpa* from green (Table 4). The test material came from a 45-year-old plantation growing in Whakarewarewa State Forest Park. The plantation had received a delayed pruning and thinning but there was considerable stem fluting. The bulk of the material was air dried in a shed in a commercial-sized stack. In addition to the dehumidification drying a range of kiln schedules was used including schedules recommended for redwood (*Sequoia sempervirens* (D. Don) Endl.) (developed for a collapse-susceptible species), and silver beech (Kininmonth & Williams 1974), plus 71°/60°C throughout. The latter was included in previous studies and allowed a comparison of plantation- and shelterbelt-grown material.

TABLE 4—Dehumidification schedules for plantation-grown **Cupressus macrocarpa** (Study 5)

| Dehumidifier conditions | | Elapsed time (days) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 9 | 10 | 11 | 13 | 15 | 18 | 20 | 22 | 24 |
| Mild | - Temperature (°C) | 30 | | 30 | | 35 | 35 | | 38 | 38 | 38 |
| | Relative humidity (%) | 85 | | 80 | | 80 | 65 | | 55 | 50 | 45 |
| Severe | - Temperature (°C) | 40 | 40 | | 40 | | | 40 | | | |
| | Relative humidity (%) | 80 | 70 | | 65 | | | 54 | | | |

## Cupressus lusitanica

*Cupressus lusitanica* is a variable species growing naturally in Mexico and several other Central American countries where it is widely distributed to altitudes of 1000–2000 m, usually on moist slopes or near streams (Streets 1962).

Until recently *C. lusitanica* has been largely ignored in New Zealand, but new findings on its silviculture and utilisation have been favourable. It may be preferred to *C. macrocarpa* on suitable sites as it is less susceptible to the common cypress canker and generally shows a rapid recovery from the disease (Jones 1954). Established stands of *C. lusitanica* do not show as much stem fluting as *C. macrocarpa* but care must be taken in selecting the seed source.

Apart from being slightly lighter in colour, the wood of *C. lusitanica* is virtually indistinguishable from *C. macrocarpa* and can be used for the same purposes. Overseas (Anon 1966) it is reported to kiln dry rapidly with a slight tendency to distort but little splitting; no mention is made of collapse or internal checking. A moderately severe kiln schedule is recommended.

Because of the small resource and the absence of commercial utilisation, the only study of *C. lusitanica* was on sawn material from a 47-year-old stand at Tairua Forest. The stand had been thinned and pruned to a height of 6.4 m. Seed for this stand came from a single tree of *C. lusitanica* growing in Rotorua, and there may have been some hybridisation with *C. macrocarpa*.

Seven well-formed trees were sawn to framing and board sizes and a random selection of material was taken for study.

The study included air drying of 0.6-m samples and 2.4-m lengths in a small covered stack, and several kiln charges the schedules of which are given in Table 5.

## Chamaecyparis lawsoniana

The *Chamaecyparis* genus includes six species in North America, Japan, and Taiwan closely allied to *Cupressus* and sometimes combined with that genus (Dallimore & Jackson 1969). In New Zealand *Chamaecyparis lawsoniana* or Lawson cypress is the most common species of this genus. It is a native of the north-western coastal states of the United States where it is most abundant and reaches its largest size on west slopes of the Coast Range foothills close to the ocean. It is not particularly exacting in its soil requirements and exhibits good stem form.

By 1981 there were just over 800 ha of *Ch. lawsoniana* planted in State forests in New Zealand, with 86% of this area being over 30 years of age (unpubl. data). Plantation-grown trees are of good form, with fine branching and a narrow pith, and are not affected by cypress canker.

Wood of *Ch. lawsoniana* has a similar colour and odour to that of *C. macrocarpa* but is somewhat finer in texture. It has moderate shrinkage and moderate natural durability, and machining properties are good. The wood has been approved by the Housing Corporation of New Zealand for the same uses as *C. macrocarpa*. A strong market currently exists for *Ch. lawsoniana* sliced veneer.

Experience in drying this species at the Institute has been confined to two studies. The first study included one small kiln-drying charge and one air-drying stack of freshly felled shelterbelt material. The kiln-drying charge consisted of 11 boards 1.8 m long and six 0.6-m sample boards. All were nominally 150 × 25 mm. Schedule details are given in Table 5.

Material for the second study came from an untended 52-year-old stand in Tairua Forest. Despite the age, the trees were all less than 60 cm diameter because of the very tight spacing. The 100 × 50-mm lengths were selected from 2 days' cutting of a portable sawmill. Details of kiln schedules are included in Table 5. Each kiln charge had 11, 0.6-m, sample boards and the dehumidifier charge also included 60 boards 3.3 m long.

TABLE 5—Kiln schedules for **Cupressus lusitanica** and **Chamaecyparis lawsoniana**

| Charge | Elapsed time (days) | Dry bulb temperature (°C) | Wet bulb temperature (°C) |
|---|---|---|---|
| **C. lusitanica** | | | |
| 1 (low temperature)* | Until dry | 38.0 | 33.0 |
| 2 | 0 | 55.0 | 52.0 |
| | 1 | 55.0 | 50.0 |
| | 3 | 55.0 | 48.0 |
| | 6 | | |
| | until dry | 55.0 | 45.0 |
| 3 | Until dry | 71.0 | 60.0 |
| **Ch. lawsoniana** | | | |
| First study | | | |
| 1 | 0 | 65.6 | 60.0 |
| | 3 | 71.1 | 60.0 |
| | 5 | | |
| | until dry | 76.7 | 76.7 |
| Second study | | | |
| 1 Dehumidification | Until dry | 38.0 | 33.0 |
| 2 Silver beech schedule | 0 | 54.5 | 49.0 |
| | 1 | 60.0 | 51.5 |
| | 2 | | |
| | until dry | 65.5 | 54.4 |
| 3 | Until dry | 71.0 | 60.0 |
| 4 | 0 | 65.0 | 60.0 |
| | 1 | 70.0 | 60.0 |
| | 2 | | |
| | until dry | 75.0 | 60.0 |

* Includes 2.4-m lengths

### × Cupressocyparis leylandii

Hybridisation of several of the cypresses occurs naturally. The best known hybrid in New Zealand is × *Cupressocyparis leylandii* (*Chamaecyparis nootkatensis* D. Don × *Cupressus macrocarpa*) or Leyland cypress. The clone which has been planted most commonly and is currently receiving most interest is "Leighton Green". This clone shows extreme vigour and is tolerant of a wide range of sites. When grown on fertile free-draining sites it is virtually unaffected by cypress canker (Sturrock 1972) and therefore has some potential in farm forestry.

Thomas (1967) reported that the wood of British-grown *Cu. leylandii* (unspecified clone) had the same favourable properties that *C. macrocarpa* exhibits, i.e., uniform texture, low shrinkage, stability, and moderate natural durability.

The only tree evaluated at the Institute was an open-grown multi-leadered 29-year-old tree of the "Leighton Green" clone.

From a random selection of the sawn timber a single series of 14 sample boards (0.6 m long, 25 mm thick) were prepared and kiln dried from green according to the recommended redwood schedule (Kininmonth & Williams 1974). This schedule was also used in the plantation-grown *C. macrocarpa* study so the results were directly comparable.

## RESULTS

### Cupressus macrocarpa

Drying times for the first study (shelterbelt material) are shown in Table 6. No collapse was apparent externally in the charge dried at 54.5°C (Charge 4), but in all other charges it was visible within 24 hours of the start of drying. Internal checking was present in all charges and there was an increase in both internal checking and shrinkage with any increase in drying temperature (Table 6). Internal checking was most severe adjacent to knots, near the pith, and in the heartwood/sapwood transition zones. Steam reconditioning at 100°C and 100% RH did not reduce collapse greatly and often caused the development of numerous end checks. Intergrown knots, particularly the larger ones, developed checks and the encased knots loosened and fell out. Clear, defect-free lengths of *C. macrocarpa* could be dried without warp but cross-grain around knots caused spring.

TABLE 6—Mean drying times, shrinkage, and internal checking for 150 × 25-mm **Cupressus macrocarpa** from shelterbelt material - 12 samples/charge (Study 1)

| Charge | Drying time to 15% m.c. (days) | Shrinkage to 12% m.c. (%) | | Internal checking frequency | | | |
|---|---|---|---|---|---|---|---|
| | | Width | Thickness | Nil | Slight | Moderate | Severe |
| 1 | 2.1 | 3.4 | 4.7 | 1 | 2 | 3 | 6 |
| 2 | 2.6 | 2.8 | 2.0 | 5 | 2 | 4 | 1 |
| 3 | 4.3 | 2.6 | 1.4 | 7 | – | 4 | 1 |
| 4 | 4.5 | 2.5 | 1.5 | 7 | 5 | – | – |

The air drying and forced air drying used in the second study eliminated internal checking but gave significant end and surface checking. Despite the use of milder kiln schedules than in the first study internal checking still caused substantial degrade, particularly in the 150 × 25-mm material (Table 7). Once again, acceleration of drying caused knot checking and loosening.

TABLE 7—Effect of drying method on severity of checking of **Cupressus macrocarpa** from shelterbelt material (Study 2)

| Drying method | Checking | | | |
|---|---|---|---|---|
| | End | Surface | Knot | Internal |
| Air drying | | | | |
| 100 × 50 mm | Severe | Nil | Moderate | Nil |
| 150 × 25 mm | Moderate | Slight | Moderate | Nil |
| Forced air | | | | |
| 100 × 50 mm | Severe | Severe | Severe | Nil |
| 150 × 25 mm | Slight | Severe | Severe | Nil |
| Kiln drying | | | | |
| 100 × 50 mm | Moderate | Nil | Severe | Slight |
| 150 × 25 mm | Moderate | Nil | Severe | Severe |
| Air drying/kiln drying | | | | |
| 100 × 50 mm | Severe | Moderate | Severe | Nil |
| 150 × 25 mm | Moderate | Moderate | Severe | Nil |

In summary, neither air, forced air, nor kiln drying of timber sawn from shelterbelts proved to be wholly satisfactory. Air drying resulted in end and surface checks, forced air drying in severe surface splitting, and kiln drying in end and internal checks. Although kiln drying after air drying eliminated internal checking, other forms of degrade were as severe as in kiln drying from green.

In Table 8 the relationship between internal checking and dry bulb temperature is summarised for the eight experimental charges in the third study. A degrade rating

TABLE 8—Incidence and severity of internal checking in 150 × 25-mm **Cupressus macrocarpa** from plantation-grown material

| Charge | Dry bulb tempera- ture (°C) | Internal checking frequency | | | | | | Charge degrade rating* |
|---|---|---|---|---|---|---|---|---|
| | | Very slight | Slight | Moderate | Moderate/ severe | Severe | Very severe | |
| 1 | 32.2 | — | 1 | — | — | — | — | 2 |
| 2 | 37.8 | — | 1 | — | — | — | — | 2 |
| 3 | 43.3 | 1 | 2 | — | — | — | — | 5 |
| 4 | 48.9 | 1 | 2 | 1 | — | — | — | 9 |
| 5 | 54.4 | 10 | 5 | — | — | — | — | 20 |
| 6 | 60.0 | 1 | 14 | 18 | — | 7 | 1 | 245 |
| 7 | 65.6 | — | 17 | 37 | — | 16 | 1 | 470 |
| 8 | 65.6 | — | 22 | 30 | 17 | 12 | 3 | 588 |

* The charge degrade rating is the sum of the ratings (1–32) for individual boards

has been included, with a numerical figure between 1 and 32 being assigned for very slight through to very severe internal checking. The charge degrade rating is the sum of the ratings for individual boards.

For the 25-mm-thick boards of this plantation-grown material there is obviously a critical temperature which, when exceeded, will result in internal checking beyond acceptable levels. That critical temperature is approximately 54°C. It should be noted that, although reducing the drying temperature to below 54°C virtually eliminates degrade, drying times are greatly increased. These two factors must be carefully balanced in any commercial situation.

In the fourth study, again involving shelterbelt material, the high level of thickness shrinkage, particularly in the two conventionally kiln-dried charges, illustrates the increasing severity of collapse as drying temperature is increased, accompanied by an increase in the incidence and severity of internal checking (*see* Fig. 1 and Table 9).

Most of the material was allocated to air drying, and both shrinkage and collapse were less than with any other drying method. Despite being dried under cover, surface checking was still a problem in air drying. Inner boards in large commercial-sized stacks may be more protected but it is unlikely that such stacks would be dried in sheds and surface checking could remain a problem.

Surprisingly, very slight internal checking was still present in three of the air-dried samples. Although undesirable, occasional slight internal checking is probably commercially acceptable. The same comments apply to any material dried under an accelerated regime. More severe schedules render a substantial portion of production

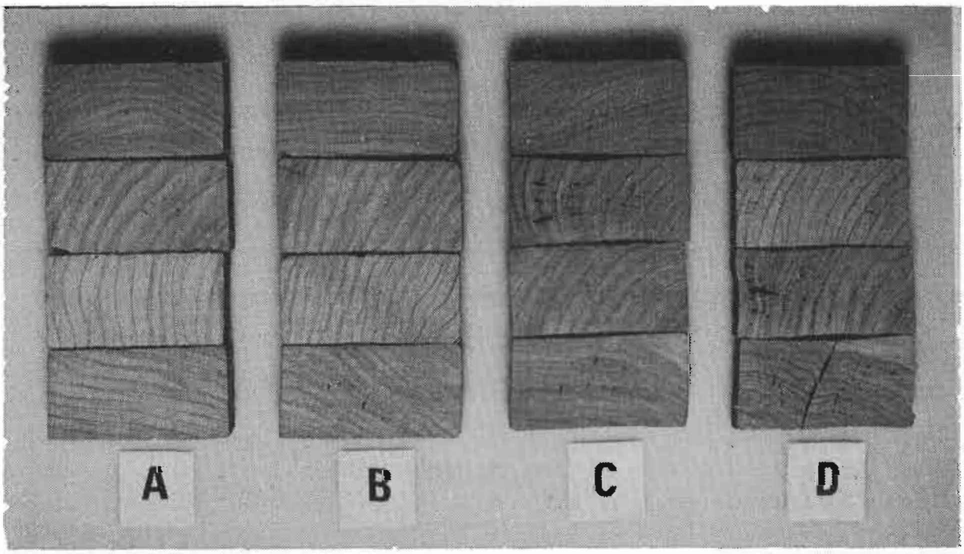


FIG. 1—Matched cross-sections of **Cupressus macrocarpa** showing increased degrade with increased severity of drying conditions: A - air drying; B - 38°/35°C to 38°/30°C; C - 54°/51°C to 65.5°/54.5°C; D - 71°/60°C.

TABLE 9—Mean drying times, shrinkage, and internal checking for 100 × 50-mm **Cupressus macrocarpa** from shelterbelt material - 16 samples/charge

| Schedule | Drying time to 15% m.c. (days) | Shrinkage to 12% m.c. (%) | | Internal checking frequency | | | |
|---|---|---|---|---|---|---|---|
| | | Width | Thickness | Nil | Slight | Moderate | Severe |
| Air dry | 187.6 | 2.1 | 2.4 | 13 | 3 | - | - |
| 38°C | 28.6 | 2.6 | 3.2 | 10 | 1 | 3 | 2 |
| Silver beech schedule | 15.9 | 3.7 | 5.8 | 2 | 6 | 3 | 5 |
| 71°/60°C | 10.9 | 4.0 | 8.5 | - | 2 | 4 | 10 |

totally unusable but even a relatively mild kiln schedule is detrimental, and also uneconomically slow. Air drying is the best means for producing acceptably dried *C. macrocarpa* but dehumidification dryers may have potential for drying the timber from green (Table 10). These operate at below 50°C and allow close control of drying conditions.

A comparison of Tables 9 and 10 shows that not only was the plantation-grown *C. macrocarpa* less susceptible to internal checking and collapse than shelterbelt material, it also dried significantly faster. Whereas surface checking during air drying of shelterbelt material had caused considerable degrade, this was not a problem with plantation-grown material. Only 4% of the plantation-grown air-dried boards had surface checking, slight in most instances (< 1 mm width) and usually associated with the pith.

TABLE 10—Mean drying times, shrinkage, and internal checking for plantation-grown **Cupressus macrocarpa**

| Thickness and schedule | Drying time to 15% m.c. (days) | Shrinkage to 12% m.c. (%) | | Internal checking frequency | | | |
|---|---|---|---|---|---|---|---|
| | | Width | Thickness | Nil | Slight | Moderate | Severe |
| **25 mm - 16 samples** | | | | | | | |
| Air dry | 84.7* | 2.2 | 1.3 | 16 | - | - | - |
| Dehumidification 1 | 19.1 | 2.7 | 2.2 | 16 | - | - | - |
| Redwood schedule | 6.6 | 3.5 | 2.4 | 11 | 3 | 2 | - |
| 71°/60°C | 5.5 | 4.0 | 8.2 | 6 | 1 | 3 | 6 |
| **50 mm - 14 samples** | | | | | | | |
| Air dry | 108.8* | 2.3 | 1.8 | 14 | - | - | - |
| Dehumidification 1 | 22.5 | 2.1 | 1.8 | 14 | - | - | - |
| Dehumidification 2 | 20.3 | 2.3 | 1.6 | 14 | - | - | - |
| Silver beech schedule | 7.7 | 3.1 | 3.4 | 8 | 5 | 1 | - |
| 71°/60°C | 5.6 | 2.9 | 5.6 | 1 | 9 | 4 | - |

* Drying time to 30% m.c.

The superior form of the plantation-grown trees plus the smallness of the knots (because of the close spacing of the stand) also meant that distortion was not a problem. In air-dried 5.1-m lengths spring was the only type of warp to cause downgrade – 6% of the lengths. Eighty-four 3.6-m lengths of 150 × 25-mm material were also dried from green to a mean moisture content of 8% in the mild dehumidification charge. Despite the low final moisture content and the stack being unweighted, only 22 lengths had excessive spring and seven excessive cup.

## Cupressus lusitanica

Comparison of Tables 10 and 11 shows that the plantation-grown *C. lusitanica* had a drying time similar to that of plantation-grown *C. macrocarpa*; shrinkages for the two species were also similar. *Cupressus lusitanica* still showed internal checking when dried from green at 71°C but the frequency and severity were less than for plantation-grown *C. macrocarpa*. Neither the low-temperature drying nor drying at 55°C caused internal checking or visible collapse. The checking of intergrown knots was directly related to the knot size and the severity of the kiln schedule. The grading rules (Standards Association of New Zealand 1978) allow for knot checks of only 1 mm width in dressing grade. Virtually all the intergrown knots checked during kiln drying

TABLE 11—Mean drying times and degrade for **Cupressus lusitanica**

| Charge and thickness | Samples | Drying time to 15% m.c. (days) | Shrinkage to 12% m.c. (%) | | Checking | |
|---|---|---|---|---|---|---|
| | | | Width | Thickness | Internal | Other |
| **Air dry** | | | | | | |
| 25 mm | 13 | 65.8 | 2.7 | 1.5 | Nil | Slight end and knot |
| 50 mm | 12 | 103.8 | 2.5 | 1.2 | Nil | Slight end and knot |
| **1** | | | | | | |
| 25 mm | 13 | 11.0 | 3.6 | 1.7 | Nil | Slight end and knot |
| 50 mm | 12 | 22.3 | 3.0 | 1.6 | Nil | Slight end and knot |
| **2** | | | | | | |
| 25 mm | 16 | 5.9 | 3.9 | 2.2 | Nil | Moderate knot |
| **3 (71°/60°C)** | | | | | | |
| 25 mm | 13 | 3.1 | 4.1 | 2.5 | 6 moderate | 6 slight surface, moderate knot |

and as a result 44% of the lengths were rejected for this. In comparison, knot checking caused the rejection of only 3% of the air-dried lengths. This points to the value of air drying where possible.

The plantation-grown *C. lusitanica* was not prone to warp. The only problem was twist, usually significant only in boards containing pith.

## Chamaecyparis lawsoniana

Air drying gave adequate drying rates with low distortion levels and no end or surface checking. Shrinkage in kiln drying in the first study averaged over the six sample boards was 5.4% tangentially and 3.5% radially at 10.6% m.c. These shrinkages are relatively high compared to the other cypresses (*see* Table 1). This may be due to the high drying temperature and the fact that the samples were not reconditioned – consequently a small component of collapse may have been present. The material was not warp-prone and the small tight intergrown knots showed only slight checking after kiln drying.

Table 12 contains details on drying times and shrinkages in the second study. No details on degrade of the samples are included because none suffered any form of checking. Compared to plantation-grown *C. macrocarpa* and *C. lusitanica* (Tables 10 and 11 respectively) *Ch. lawsoniana* dried more quickly and was less prone to degrade – it suffered no degrade even when dried from green at 71°C. An additional 15 sample boards were high-temperature dried at 120°C dry bulb, 70°C wet bulb. Of these boards only nine suffered slight collapse and internal checking, whilst the remainder were completely free from degrade. Because of the suppressed state of the forest stand and hence the small branch size, warp of the 3.3-m lengths was not a problem. Of the 60 long lengths five had excessive spring and four excessive twist. Altogether seven separate lengths were rejected for excessive warp.

## × Cupressocyparis leylandii

× *Cupressocyparis leylandii* dried relatively quickly without major degrade. None of the boards suffered visible collapse and only one had slight internal checking. These results can be contrasted with those for *C. macrocarpa* dried on the same schedule – five of 16 plantation-grown *C. macrocarpa* samples showed slight to moderate internal checking and collapse (Table 10).

As with the other cypresses, *Cu. leylandii* had a low shrinkage.

TABLE 12—**Chamaecyparis lawsoniana** kiln drying times and shrinkage (mean of 11 samples)

| Charge | Drying time to 15% m.c. (days) | Shrinkage to 12% m.c. (%) | |
|---|---|---|---|
| | | Width | Thickness |
| 1 Dehumidifier | 12.9 | 2.6 | 2.3 |
| 2 Silver beech schedule | 5.0 | 2.9 | 2.8 |
| 3 71°/60°C | 4.2 | 3.0 | 2.9 |
| 4 | 3.7 | 3.3 | 3.1 |

## CONCLUSIONS

The increasing acceptance of cypresses for future specialty wood use has increased the importance of the studies reported in this paper. Successful utilisation of specialty timbers is dependent upon an adequate supply of high-quality material free from drying degrade. Despite a similarity in most aspects of processing, wood of the cypress species exhibits considerable variation in drying properties, which means that unless they are carefully air dried to under 30% m.c. prior to final kiln drying it will be necessary to dry most of the cypress species individually.

*Cupressus macrocarpa,* which to date has been the most widely planted and subsequently the most widely utilised cypress species, has proved to be particularly difficult to dry successfully, although there are indications that plantation-grown material is less susceptible to collapse and internal checking than material from over-mature shelterbelts. The severity of this type of degrade depends upon initial drying temperatures; those over 30°C accentuate its occurrence. However, even if it is air dried, shelterbelt material can still suffer from collapse and internal checking. Open-grown material which is currently being utilised also has large knots, and consequently knot checking and grain deviation (causing warp) commonly result in more degrade than for plantation-grown material.

It is recommended that over-mature shelterbelt *C. macrocarpa* be carefully air seasoned in protected stacks down to 30% m.c. prior to final kiln drying. Plantation material may be kiln dried from green if temperatures are kept below 40°C for a substantial portion of the drying cycle. Close control of humidity is also required.

*Cupressus lusitanica* has low shrinkage during drying but, unike overmature shelterbelt-grown *C. macrocarpa,* it does not suffer from internal checking and gross collapse when kiln dried from green. It may be kiln dried from green at temperatures below 45°C without excessive internal checking, but other factors (such as variability of drying rate and the checking of intergrown knots) may make it preferable to air dry to approximately 30% m.c. prior to kiln drying. It may then be dried at settings of up to 60°C dry bulb, 50°C wet bulb.

On the basis of this preliminary investigation *Cu. leylandii* appears to be similar to *C. lusitanica* in its drying properties. Both these species may be low-temperature (below 45°C) dried from green without major degrade, but preliminary air drying prior to kiln drying is recommended.

*Chamaecyparis lawsoniana* exhibits moderate to low shrinkage and is not prone to either internal checking or collapse when kiln dried from green. Consequently, it is recommended that this species be kiln dried from green at 71°C dry bulb and 60°C wet bulb.

Wood of all the cypress species has low shrinkage, moderate natural durability, and high stability, making it suitable for a range of specialty uses including weatherboards and exterior joinery. Provided the processor is familiar with the species and source of timber to be dried, and chooses the correct procedure, drying of the cypresses should not be a problem. In general, preliminary air drying to 30% m.c. followed by final kiln drying will give the best results.

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