COMPARISON OF THE PILODYN AND TORSIOMETER METHODS FOR THE RAPID ASSESSMENT OF WOOD DENSITY IN LIVING TREES

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ABSTRACT

Two experiments were carried out to evaluate the "Pilodyn Wood Tester" (which operates by measuring the penetration of a steel striker pin) for non-destructive assessment of wood density in living trees. Results were compared with those from the recently developed Torsiometer method as regards accuracy for predicting the wood density measured from increment cores.

In the first trial, 10-year-old radiata pine clones were tested (25 clones, 5 ramets/clone, 2 measurements/ramet). The Pilodyn was by far the most rapid method and the penetration data gave a correlation coefficient of —0.96 with wood density on a clone mean basis. The Torsiometer gave a correlation of 0.78.

The second study was in a 31-year-old radiata pine plantation where 25 stems were assessed at four breast height sampling points by the three methods used in the first trial. Again the Pilodyn results were obtained more rapidly and were more closely related to mean tree outerwood density ($r = -0.86$ as compared to 0.79 for the Torsiometer).

The Pilodyn Wood Tester appears to have a high potential for the rapid measurement of wood density in large numbers of stems and would be particularly useful for ranking groups of trees such as clones or families by density classes.

INTRODUCTION

Wood density is an important timber characteristic which is being increasingly considered in radiata pine tree breeding programmes along with vigour, form, branching and health. However, because it is by far the most expensive of these traits to measure on a large scale, on account of the time involved, it is often not assessed.

Rapid methods of measuring wood density in standing trees are much sought after and recent years have seen the development of the Torsiometer technique (Fig. 1) whereby the force required to turn an increment borer is recorded with the aid of a torque-measuring device (Polge and Keller, 1970; Harris *et al.,* 1976a; Nicholls and Roget, 1977; Young, 1977). This system still necessitates the use of an increment borer in the field but greatly reduces the laboratory workload.

The Pilodyn Wood Tester (Fig. 1) was originally developed in Switzerland to obtain quantitative data on the degree of soft rot in wooden poles. The test involves

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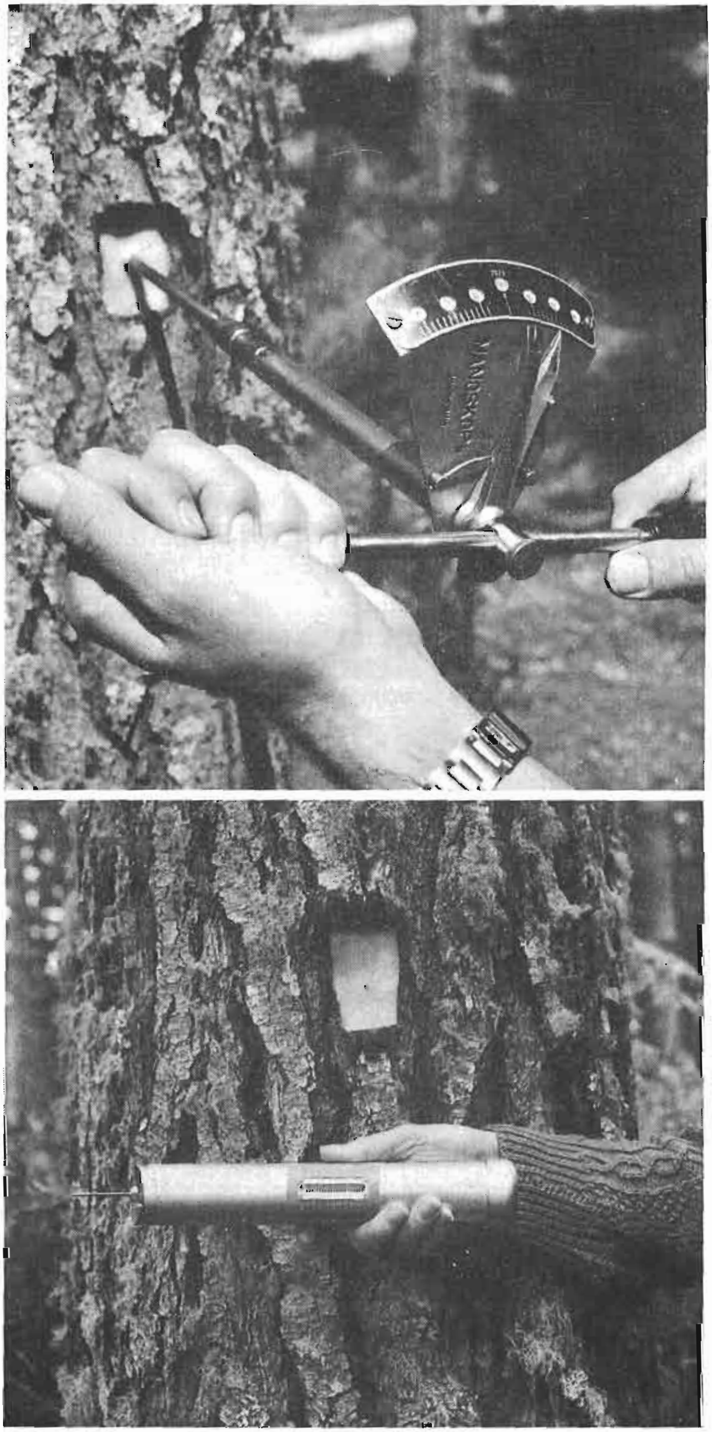

FIG. 1 (Upper)—Torsiometer attached to increment borer bit. (Lower) Pilodyn Wood Tester.

injecting a spring-loaded striker pin into the wood and reading the depth of penetration off a scale on the body of the instrument. Hoffmeyer (1978) reported results of a small-scale trial using the Pilodyn to estimate the wood density of *Abies alba* trees. A correlation coefficient of 0.71 was obtained for the data relating penetration depth to the density of increment cores. This principle is attractive in that it is rapid, does not require the use of an increment borer, and should be free of operator bias. The following studies were undertaken to examine the relationship between penetration depth and wood density of standing trees of *Pinus radiata* D. Don, using a Pilodyn with a 6-joule spring and 2.5-mm diameter striker pin.

MATERIALS AND METHODS

1. *Assessment on 10-year-old Trees*

Ramets from 206 radiata pine clones were established in Cpt. 1350, Kaingaroa Forest in 1968 in randomised blocks. Thus at the time of the current assessment the cuttings had been in the field for 10 years. Density values were calculated from increment cores at a 1974 measurement (Wilcox *et al.,* 1975) and these data were used as a basis for the selection of 25 clones covering the full range of densities in the trial. Five ramets from each of the 25 clones were identified at random on a plan of the area and these were to be tested with the Pilodyn, Torsiometer and increment cores. At each ramet, two bark strips (20 mm × 50 mm) were removed from opposite sides of the stem at breast height and this defined the test areas within which all measurements and cores were taken. Three of the clones had to be subsequently discarded due to high mortality.

In the laboratory the outer three complete growth rings were assessed for wood density by the maximum moisture content method (Smith, 1954).

2. *Assessment in a 31-year-old Stand*

As the Pilodyn operates by penetration, there was a suspicion that its action might be affected by the number of latewood bands encountered, as latewood density in radiata pine is appreciably greater than that of the earlywood, and the contrast increases with distance from the pith. A 31-year-old stand in Cpt. 10 Whakarewarewa State Forest Park was chosen to test the suitability of the instrument for assessing density in older stands. Methods adopted were the same as for Experiment 1 except that four sample points per tree were tested from each of 25 stems in order to compare the ranking of individual trees by density with the Pilodyn and Torsiometer results.

In the laboratory the outer 20 mm of each increment core were used for density determination.

RESULTS

(1) Results for the 10-year -old clonal trees are plotted in Fig. 2 to illustrate the relationships between wood density and the Pilodyn and Torsiometer readings. Both correlation coefficients were very highly significant but the Pilodyn regression line accounted for 92% of the observed variation compared to 61% for the Torsiometer. This latter result compares favourably with the 55% given by Harris *et al.* (1976a) for

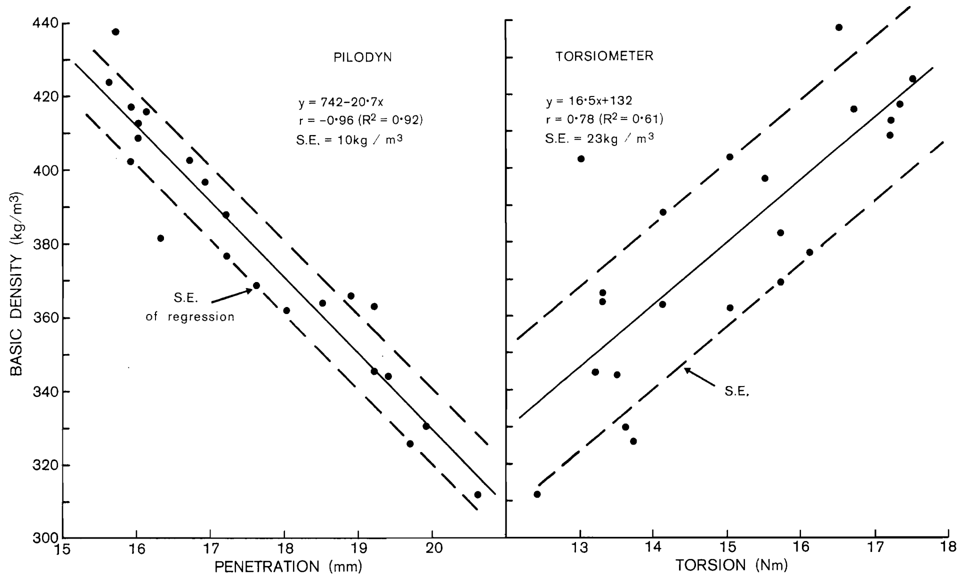

FIG. 2—Comparison of Pilodyn and Torsiometer assessments of Clonal Trial 944/4.

an 8-year-old stand but less so with the 88% given by Young (1977) and the very high correlations (0.93-0.95) reported by Nicholls and Roget (1977) in young radiata pine. The Pilodyn results were very satisfactory and ranking by clonal mean densities corresponded closely to the ranking by penetration depth, with a few minor exceptions (Fig. 3).

The slopes and intercepts of within-clone Pilodyne regressions, based on a small number of observations, indicated that the relationships are similar to the overall regression.

(2) Mean values for Pilodyn and Torsiometer assessments of trees in the 31-year-old stand are plotted against wood density in Fig. 4. In this case the Pilodyn correlation was —0.86 ($R^2 = 0.74$), compared to 0.79 ($R^2 = 0.62$) for the Torsiometer results. Clearly, ranking by Pilodyn would be more closely related to density trends than ranking by Torsiometer results.

The average number of growth rings in the outer 20 mm of wood varied from 2.0 to 11.2. With a penetration/density correlation coefficient as high as —0.86 it would not be worthwhile trying to improve on it by taking account of any influence of growth rate.

DISCUSSION AND CONCLUSIONS

The two experiments described here indicated that the Pilodyn instrument can be satisfactorily applied to the assessment of wood density in living trees of radiata pine. It would appear that the method has some considerable advantages over both the traditional systems of collecting increment cores and the more recently adopted Torsiometer method.

Speed, both in the field and in the laboratory, is the main criterion limiting the amount of density assessment which can be undertaken in tree improvement trials. In

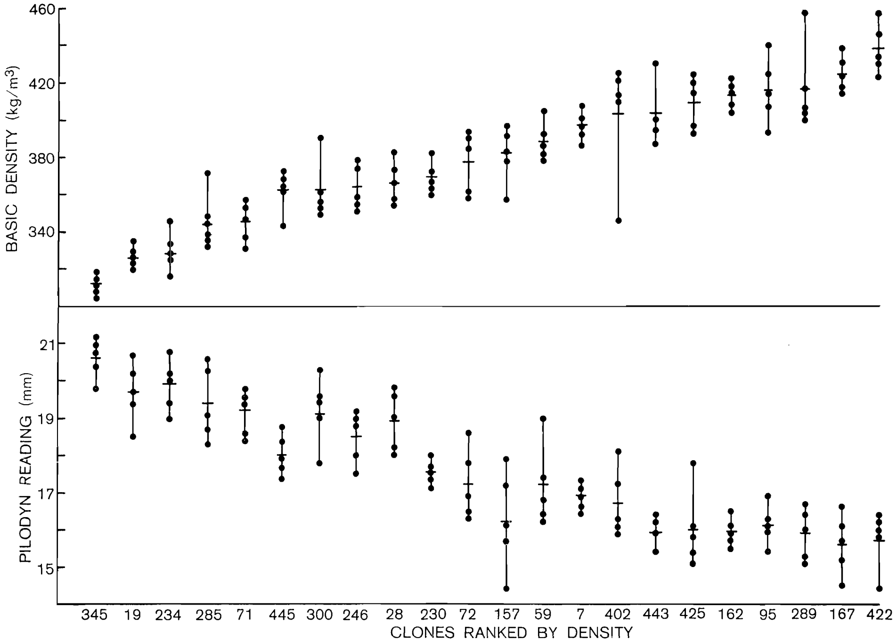

FIG. 3—Ranking of clones by wood density and the corresponding Pilodyn data.

this respect the Pilodyn is outstanding, particularly in young stems where bark removal is easy and rapid. In older trees the thick bark must be punched out with the aid of a chisel or similar instrument and this can be more time-consuming. However, this practice is also recommended for efficient Torsiometer operation (Nicholls and Roget, 1977; G. D. Young, pers. comm.). Once the bark strip has been removed the Pilodyn is simply placed against the wood surface and the end pushed to release the striker pin. Penetration depth can be read in a matter of seconds from the scale on the instrument. An additional advantage of having a "window" on the stem is that compression wood is noticeably darker in appearance than normal wood, at least during latewood formation, and can be avoided if necessary. Use of the Torsiometer requires insertion and removal of an increment borer, which is not only much more time-consuming but introduces an extra source of error, namely the condition of the cutting edge (Harris *et al.,* 1976a).

Some of the main problems in Torsiometer operation arise from operator bias caused both by varying force applied to the tool handles and different interpretation of the pointer position on the scale. The latter source of error also applies to the Pilodyn method but the former, and probably more important source is overcome since the release mechanism is independent of the applied pressure. Also, continuous operation does not introduce a fatigue factor as can occur with the Torsiometer.

Damage to standing trees caused by the Pilodyn is much less than that resulting from Torsiometer operation and consists of a hole 2.5 mm in diameter and up to 20 mm deep. An increment borer used for extracting 5 mm diameter cores leaves a channel about 11 mm in diameter and at least 40 mm deep.

The main application of the Pilodyn in wood density assessment is seen as being in the field of tree breeding where density is considered to be a trait worth improving (Wilcox *et al.,* 1975). Several studies have shown that this characteristic is more highly heritable than any of the others included in current programmes (Harris *et al.,* 1976b) but unfortunately the measurements required are often prohibitively time-consuming in large scale trials. The Torsiometer reduces the overall work load by limiting the laboratory time as compared to increment core methods, but the field effort is essentially similar. The Pilodyn can reduce field time considerably, as operation of the instrument is much more rapid. It also appears to be more accurate for estimating wood density. Density can be estimated to within $\pm$ 20 kg/m^3 at the 95% confidence level (Fig. 2).

This report shows that group means can be ranked very satisfactorily into density classes using the Pilodyn. Trees could also be ranked providing sufficient samples per tree are collected. The limiting factor in this case is not only the penetration/density relationship but the unpredictable circumferential variation found in tree stems (Cown, 1971). In Fig. 4 the standard error of the regression is shown to be 16 kg/m^3.

A disadvantage of both the Pilodyn and Torsiometer instruments is the relative insensitivity of the scales and the consequent potential error in interpreting between narrow limits. In practice it will probably be unrealistic to record Pilodyn results at better than 0.5-mm intervals, despite the fact that 1 mm represents about 20 kg/m^3 in density. Where large numbers of samples are being averaged this effect will be negligible but with small sample numbers such as in individual tree comparisons, the errors will be larger. As a result of this insensitivity it is absolutely essential that the bark be removed prior to testing since bark thickness can vary appreciably from tree to tree.

Tree species, age and growing conditions have been shown to influence the relationship between wood density and the torque required to turn an increment borer (Young, 1977) and it is likely that the same factors will also affect the Pilodyn results to some

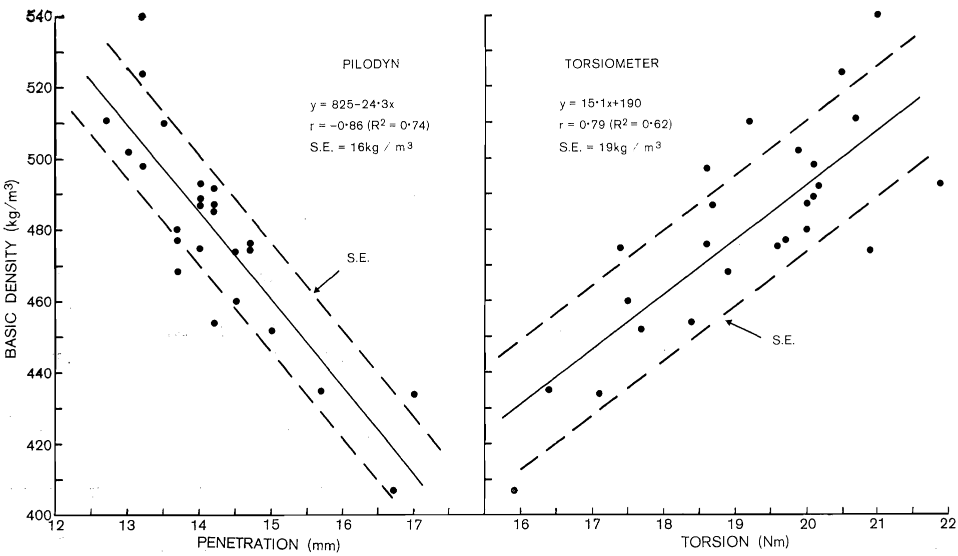

FIG. 4—Comparison of Pilodyn and Torsiometer assessments in Cpt 10 Whaka Forest.

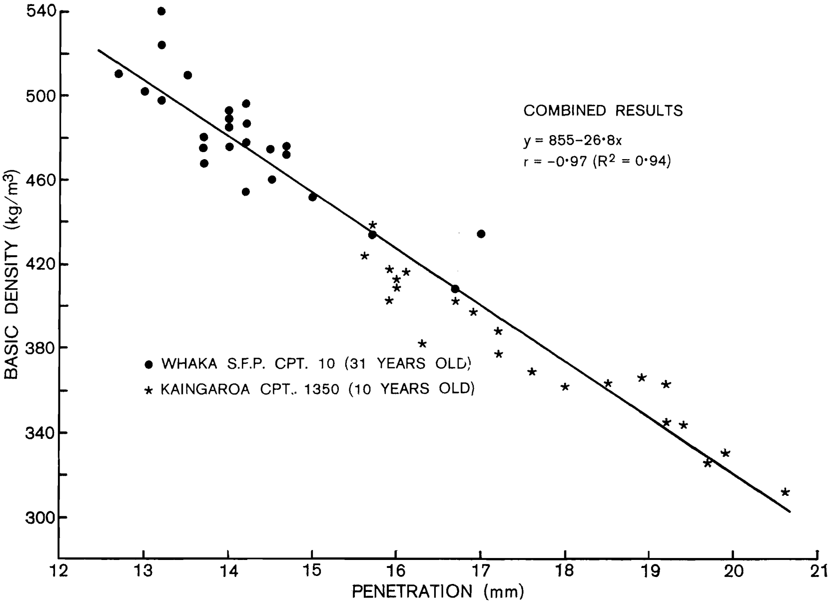

FIG. 5—Combined Pilodyn results for Experiments 1 and 2.

extent. The combined data for the two experiments reported here (Fig. 5) suggest that in fact an overall regression line may be applicable over a wide range of ages and possibly site types in radiata pine. Nevertheless, for situations in which absolute density values are of interest, periodic checking with increment core samples would be advisable.

With increasing use of the Pilodyn Wood Tester it may be necessary to experiment with different types of spring or striker pin sizes to improve the sensitivity, particularly if the more dense hardwoods are to be tested.

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Note in proof

Subsequent work with the Pilodyn instrument has indicated a possible seasonal effect, the results being poorer during the period of most active cambial growth. Investigations on this aspect are continuing.