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Short communication

An improved tool for the fabrication of dendrometer bands to estimate growth as function of treatments in slow growing native *Prosopis* stands

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Abstract

Silvicultural research on slow growing hardwoods, especially hardwoods in semi-arid ecosystems is complicated by the slow growth rates that require long time periods to measure treatment responses. Difficulty in measuring small growth increments with traditional methods results in large measurement errors requiring many replications over long time spans. Permanently mounted dendrometers with a vernier scale can detect diameter changes of 0.25 mm (0.01 in.) and are useful tool for these applications. A tool described by Liming [Liming, F.G., 1957. Homemade dendrometers, J. For. 55, 555–577.] can be used to construct inexpensive, precise dendrometers. Unfortunately this tool is difficult to fabricate due to the very thin slots 0.254 mm (0.01 in.). Additionally, the stylus for this dendrometer is very narrow (<0.25 mm) and not very robust. We report a design for a dendrometer whose slots are five times as wide that is easier to fabricate. The stylus for the new dendrometer is machined on a lathe and is five times thicker and more robust. This paper reports the use of this dendrometer that can measure increase or decrease of 0.25 mm (0.01 in.) in diameter. When used in conjunction with sampling and regression equation development, this system measured significant treatment differences in growth for total biomass and volume in stands that only grew from 1.2 to 2.7 mm in basal diameter per year.

Keywords: Allometric; Biomass production; Sylviculture; Tree growth

1. Introduction

Measurements of treatment effects on tree growth in semi-arid ecosystems are complicated by large variability and slow tree diameter growth (less than 2 mm per year) (Patch and Felker, 1997) that is below the detection limits of annual measurements using diameter tapes. Dendrometers that are permanently mounted on trees greatly reduces measurement error, which facilitates increased statistical efficiency and permits shorter evaluation periods than possible with conventional methods.

A previously reported tool described by Liming (1957) for fabrication of dendrometers provided a technique for inexpensive fabrication of dendrom-

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eters. Perhaps due to the difficulty in constructing the accurately machined, very thin slots 0.254 mm (0.01 in.) and the delicate nature of the thin stylus <0.254 mm (0.01 in.), Liming's dendrometer has not been in wide use. This improved version has slots five times wider and thus is easier to machine. The greater slot width also permits the use of round pointed stylus machined on a lathe that is more robust.

Even with inexpensive dendrometers they often cannot be placed on all the trees in sample plots. Thus a sampling scheme must be used. We illustrate the use of this dendrometer for slow growing *Prosopis* in an overall strategy for sampling, regression equation development for treatments, and prediction of stand growth as a function of treatments.

2. Materials and methods

In Fig. 1, one can see the dendrometer band permanently attached to the tree. We fabricated the 25.4 mm wide (1.0 in. wide), no. 30 gauge dendrometer bands from painted aluminum sheeting sold locally for exterior use on housing. The most expensive part of the dendrometer was the 3.8 cm (1.50 in.) long, 0.64 cm (0.25 in.) diameter stainless steel spring obtained from Tri-Corr Industries, Philadelphia, PA, USA. The loose bark was scraped from the tree and an unmodified strip was placed around the tree to estimate the length. Heavy-duty metal shears (tin snips) were used to cut this 30 gauge metal so it would overlap about 15 cm (6 in.) length. About half the width of one end of the strip was cut out where the inscribed portions of the vernier were to line

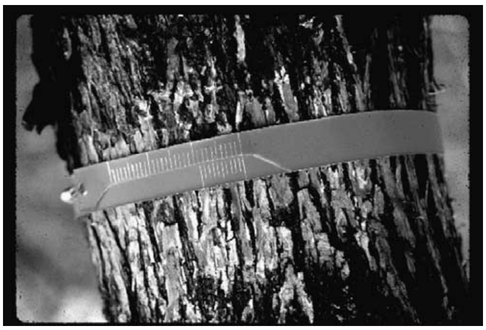

Fig. 1. Painted aluminum dendrometer band permanently attached to a *Prosopis* tree trunk after the loose bark was scraped off.

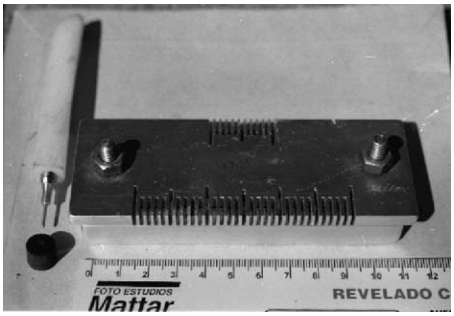

Fig. 2. Improved tool for making dendrometer bands. The stylus used to inscribe the bands is to the left. Dimensions are as noted in the text.

up. The tool was used to inscribe the verniers, the strip punched to install the spring and the vernier placed on the tree. The strips were capable of reading to 0.25 mm (0.01 in.).

The improved tool used to make the dendrometers bands is shown in Fig. 2. The slots on the earlier Liming (1957) version were 0.254 mm (0.01 in.) in width and the stylus in the earlier version was less than 0.254 mm (0.01 in.) in thickness. Our version was improved by using slots of 1.27 mm (0.05 in.) wide, which are much easier to make using a slitting saw. The previous design used a very thin (<0.254 mm) piece of tempered steel sharpened like a chisel and inserted into a penholder for a stylus. Our design used a much more robust stylus machined in the form of a cylinder from high carbon steel on a lathe. The diameter of the stylus was 1.016 mm (0.04 in.) and it had a machined point exactly in the center of the cylinder. This hand tool was used as a scribe to mark the dendrometer bands.

The template portion of the tool consisted of a bottom and top plate into which the opposite ends of the dendrometer band were placed and secured with the nuts. On one side of this device were 31-machined slots over a distance of 76.2 mm (3.00 in.). The centers of these slots were 2.54 mm (0.100 in.) apart with longer slots at 12.7 and 25.4 mm (0.500 and 1.000 in.). On the other side of the device were 11 slots that spanned a distance of 22.86 mm (0.900 in.). The centers of the slots on this side were spaced 2.286 mm (0.0900 in.) apart.

Typically the dendrometers were read on a monthly basis. For *Prosopis* we found that the trees only grew for 3 months of the year in spring and early summer

Table 1
Mean and 95% confidence intervals for *Prosopis glandulosa* diameter growth, annual volume increment and percentage increase in volume in a mature native stand over a 9-year period (Patch and Felker, 1997)

Treatment	Mean basal diameter growth per year, mean ± 95% confidence interval (mm)	Annual volume growth (m^3 ha^{-1})	Increase in volume/initial volume (%)
Control	1.2 ± 0.19	0.291	13.3 CC
Thinning	2.2 ± 0.61	0.248	21.4 BCB
Thinning plus understory removal	2.2 ± 0.06	0.373	25.9 BAB
Thinning plus understory removal plus herbicide treatment of understory	2.3 ± 0.54	0.307	26.6 ABAB
Thinning plus understory removal plus herbicide treatment of understory plus phosphorus fertilization	2.7 ± 0.87	0.387	34.9 AA

Means followed by the same letter are not significant at the 0.05 level ($n = 4$) as determined by Tukey's HSD.

(Cornejo-Oveido et al., 1992) and that in extended droughts or some winters the tree diameter decreased. After the trees grew 7.5 cm in diameter, it was necessary to install another dendrometer.

It is important to place the use of this tool in the context of a sampling/regression scheme. We will use our experience with slow growing native stands of the arid tree *Prosopis* to illustrate the utility of this device. Even with the rapid and inexpensive nature of these dendrometers, it was not practical to install dendrometers on all trees. We took a pragmatic sampling approach and measured the diameter of all the trees in the study plot, ranked them in terms of diameter and installed dendrometers on every fifth tree going from the largest to smallest tree. Thus the dendrometer placement was stratified in relation to tree diameter.

To estimate the growth for the trees that did not have dendrometers, we developed a regression equation for each treatment between initial diameter and growth at a specified time period after initiation of the treatment. In the case of *Prosopis*, we used the regression equations of El Fadl et al. (1989) to predict total biomass, volume or standing sawn timber as a function of diameter for each tree. Then we developed a new regression equation, specific for that treatment, between the stem diameter before treatment and growth at the later time period. This equation was applied to the initial basal diameter of the 80% of the trees within the same treatment that did not have dendrometers installed. We assumed that 20 trees per treatment regression would be acceptable as the trees were stratified over the diameter range and as this would provide 18 degrees of freedom for the regression (Patch and Felker, 1997). In our trials these 20 'dendrometer/regression trees' were assigned approximately equally to each of the four blocks of the same treatment.

While this approach provided an estimate of the total growth of each treatment, it suffered from the fact that not all the treatments in this native stand had the same initial basal area. To normalize growth rates on the basis of initial basal area, we also compared the absolute growth to the percent relative weight and volume growth. These latter values were determined from the increase in weight or volume divided by the total initial weight or volume.

3. Results and discussion

In summary, this tool permits the fabrication of dendrometer bands directly in the field for an individual material cost of less than $ 2 each and is capable of measuring the growth in circumference of the trees to about 0.25 mm (0.01 in.). As can be seen in Table 1, in spite of small annual diameter increments of 1–2 mm, this tool was able to detect significant differences in growth rates among treatments. When this tool was combined with the above described sampling/biomass estimation strategy, it was possible to measure differences in biomass growth, annual volume growth and significant differences in the growth rate of the stand corrected for initial basal area (Patch and Felker, 1997).

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