

## BRIEF NOTE

# Construction of a Circular Plot Sampling Instrument<sup>1</sup>

Allan M. Hale, RUST Environment & Infrastructure, 11785 Highway Drive, Suite 100, Cincinnati, OH 45241

**ABSTRACT.** The use of individual and nested circular plots for plant ecology studies has increased in recent years. This method is efficient for sampling vegetation but suffers from problems inherent in the use of chain or rope sampling devices to determine the edge of the circular plot boundary (especially in areas of moderate to dense shrub and tree cover). This note describes the construction of a circular plot sampling instrument with improved adjustability, and ease of use over other methods. The instrument is adaptable to a wide variety of field situations. Because it is optically based, the circular plot sampling instrument and prism provide rapid indication of circular plot boundaries anywhere within sight of the plot sampling instrument.

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## INTRODUCTION

Establishing nested circular sampling plots in forests or shrublands can present difficulties to the plant ecologist. A common circular plot sampling method uses a central point around which a chain or rope of varying length is pivoted to determine the edge of the circular plot (Baker and Pearson 1981, Brown 1974). This method has the inherent disadvantage of requiring the investigator to thread the rope back and forth around vegetation within the plot.

One method used by field personnel to overcome this problem uses a center post and an optical tape measure to measure the boundary of the plot (Hays et al. 1981). One drawback to this method (based on personal experience) is that optical tape measures are delicate. In addition, depending on the instrument, measurement errors can become substantial if the instrument is not calibrated several times a day while in the field. Additionally, some instruments such as the "Swiss rangefinders," can be quite expensive and cumbersome in the field (Freese 1962).

Other field methods involve the use of prisms with various fixed distance target pole configurations (White and Lewis 1982, Korhonen 1979, Nyland and Remele 1975, Lemmon 1958). These methods are designed for fixed circular plot areas and lack the flexibility of being field adjustable for differing site plot size conditions.

This note describes the development, fabrication, and field evaluation of an instrument that would overcome the drawbacks previously described, which uses an optical prism (basal area factor prism) as a rangefinder. The operation of the instrument is based on well established forest mensuration methods including Barbour et al. 1987, Avery 1975, Freese 1962, Phillips 1959, Grosenbaugh 1952, Bitterlich 1948.

## MATERIALS AND METHODS

The sampling point instrument illustrated (Fig. 1) provides a method of rapidly establishing the boundaries

of individual or nested circular plots. The theory of the instrument is based on the critical angle measurement (angle of deflection) characteristics of optical (basal area factor) prisms as described by Hovind and Rieck (1970). A known diameter or basal area can be measured at a specific distance when using an optical prism (Mueller-Dombois and Ellenberg 1974, Cain and Castro 1971). If the plane of optical alignment is rotated 90° to the vertical (from horizontal to vertical) and the optical prism is also

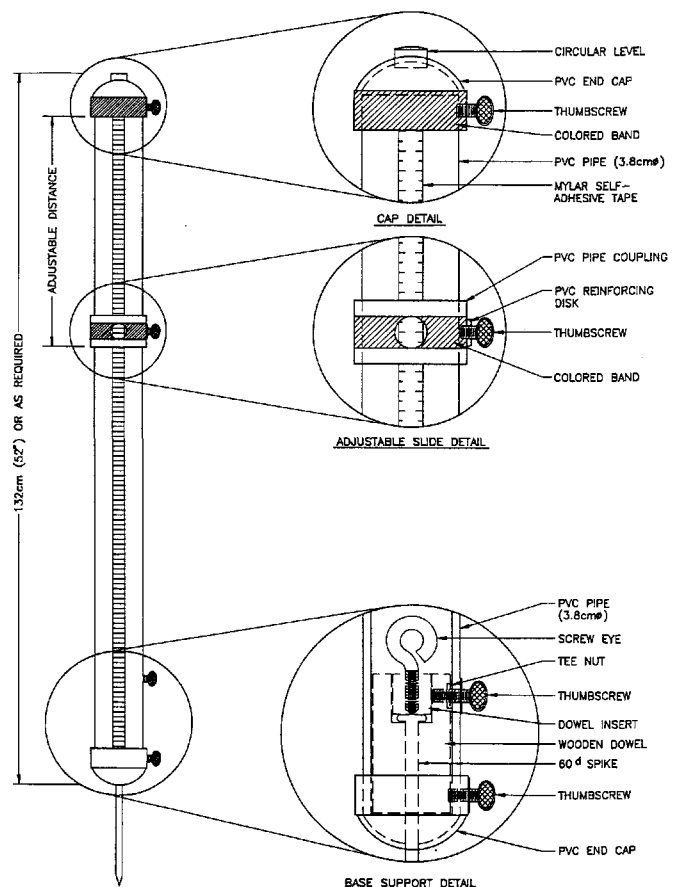


FIGURE 1. Adjustable circular plot sampling instrument construction details. Dimensions may be altered to suit the individual plant ecologist's requirements.

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rotated 90° in the same plane, then measurement distances established on a vertical plane can be aligned the same way as those measured in the horizontal plane. For this application, if an optical prism with known basal area factor (BAF) is used to measure a fixed distance in the vertical plane, at the point of image convergence (alignment), the observer will be located at a fixed radius from the central measurement point, regardless of the direction he finds himself from the sampling point instrument.

The circular plot radius (m) can be determined where:

$$r = \sqrt{\frac{A}{\pi}} \tag{eq-1}$$

*r* = Circular plot radius (m)

*A* = Desired circular plot area (m<sup>2</sup>)

The plot radius factor (cm) can be calculated for an individual prism:

$$Prf = \frac{r}{Ts} \tag{eq-2}$$

*Prf* = Plot radius factor (cm) for an individual prism

*r* = Circular plot radius (m)

*Ts* = Target spacing (cm)

Target spacing is defined as the distance between the colored bands on the top endcap and the adjustable slide on the sampling instrument. The plot radius factor metric conversion for English unit BAF prisms is calculated where:

$$Prf(cm) = \left(\frac{BAF}{1}\right) \left(\frac{0.3048\ m}{2.54\ cm}\right) \tag{eq-3}$$

*Prf* = Plot Radius Factor (cm)

BAF = Individual prism basal area factor value (Table I)

If desired, the target spacing for the sampling point instrument for any calculated metric circular plot area can be calculated by:

$$Ts = \frac{r}{Prf} \tag{eq-4}$$

*Ts* = Target spacing (cm)

*r* = Circular plot radius (m)

*Prf* = Plot radius factor (cm)

If the area of a circular plot is calculated it is possible to establish the fixed distance relationship for the circular plot size required (eq-2, 3, and 4) (Chambers and Brown 1983). Several plot sizes, and target spacing lengths are provided (Table 1). In the field, the center point for the nested circular plots can be established and the adjustable slide of the instrument can be set for the desired circular plot size. The investigator then walks to the edge of the circular plot radius (Table I) and using the optical prism determines the optical alignment point for the plot edge which can be marked with flagging or lath.

The sampling point instrument design described here resulted from experimentation with wooden lath, metal pipe, and steel rod as sampling point targets. While each of these materials was functional, none was easily adjustable, each lacked flexibility and, in some field situations, exhibited poor visibility due to size and/or color. The instrument described is based on progressive refinements for features desired by field ecologists. The design and dimensions for the adjustable sampling instrument are provided (Fig. 1). The instrument is constructed of readily available materials and can be easily modified for individual requirements.

The instrument body is constructed of polyvinyl chloride (PVC) plastic pipe, with an inside diameter of 3.81 cm (1.5 in). The pipe is cut to a 132 cm (52 in) length

TABLE 1

*Circular plot target spacing for sampling point instrument.*

Plot Size	Plot Radius (m)	BAF Prism Types						
		BAF-10	BAF-15	BAF-20	BAF-25 (-cm)-	BAF-30	BAF-35	BAF-40
0.01 Hectare	5.64	17.1	21.0	24.2	27.0	29.5	32.1	34.2
0.02 Hectare	7.98	24.2	29.7	34.3	38.2	41.8	45.3	48.4
0.025 Hectare	8.92	27.0	33.2	38.3	42.7	46.7	50.7	54.1
0.033 Hectare	10.30	31.2	38.3	44.2	49.3	53.9	58.5	62.4
0.05 Hectare	12.62	38.2	46.9	54.2	60.4	66.1	71.7	76.5
0.1 Hectare	17.84	54.1	66.3	76.6	85.4	93.4	101.4	108.1
0.2 Hectare	25.23	76.5	93.8	108.3	120.7	132.1	143.4	152.9
0.25 Hectare	28.21	85.5	104.9	121.1	135.0	147.7	160.3	171.0
0.5 Hectare	39.89	120.9	148.3	171.2	190.9	208.9	226.7	241.8
1.0 Hectare	56.42	171.0	209.7	242.2	270.0	295.4	320.6	341.9
Plot Radius Factors		BAF-10	BAF-15	BAF-20	BAF-25	BAF-30	BAF-35	BAF-40
Metric =		0.33	0.269	0.233	0.209	0.191	0.176	0.165
English =		2.75	2.245	1.944	1.739	1.588	1.47	1.375

Plot Radius is in meters from center point.

Target Spacing is the number of centimeters between color bands.

(or as desired) end to end. A PVC endcap is used to terminate the pipe at each end. The top endcap is drilled to attach a small circular "bulls-eye" level (Fig. 1). One side of the endcap and the inner pipe body are drilled to accept a small thumbscrew. The endcap thumbscrew hole should be slightly larger in diameter than the inner pipe hole so the thumbscrew can be threaded into the inner pipe for a secure closure. A 2.54 cm (1.0 in) width of brightly colored vinyl tape is fastened around the outer rim of the top endcap.

After the top endcap has been fastened to the pipe body with the thumbscrew, a mylar<sup>™</sup>-coated, adhesive-backed measuring tape (available from hardware dealers) is fastened to the outside of the pipe body.

The base support cap (Fig. 1) allows the support spike to be used in an open position or reversed inside the bottom cap for transport or storage of the instrument. The spike consists of a 60<sup>l</sup> (penny) steel spike, centered in a wooden dowel, that is sanded for a snug fit inside the pipe body (Fig. 1). A small amount of epoxy adhesive is applied to the base of the spike head hole. The spike is inserted and seated in hole and additional epoxy is placed around the spike and along the inside walls of the hole. The small dowel is then inserted into the hole and tapped until it seats above the spike. A pilot hole can then be drilled into the center of the small dowel to accept a 6.3 or 9.5 mm (1/4 or 3/8 in) screw eye.

The dowel assembly is then positioned inside of the bottom end of the pipe body with the wooden dowel flush with the end of the pipe, and a small pilot hole is drilled through the pipe into the dowel. This hole is then enlarged to permit passage of a 6.3 mm (0.25 in) diameter thumbscrew. The dowel assembly is then removed from the pipe body and a hole large enough to accept a tee nut fastener with the same thread size as the 6.3 mm (0.25 in) thumbscrew is drilled. Some additional sanding around the tee nut may be needed to allow it to slide inside of the pipe body. When the hole has been drilled, and the surrounding area sanded, the tee nut is inserted into the hole along with a small amount of epoxy. After completion, the dowel assembly can be inserted into the pipe body and, when aligned with the tee nut hole, the thumbscrew can be tightened to secure the assembly to the pipe body.

The same construction procedure described for the top cap is performed for the bottom endcap to install a small thumbscrew. After the thumbscrew hole is drilled, and the pipe body threaded, the thumbscrew is inserted and tightened to secure the endcap.

Construction of the adjustable slide is the last activity required to fabricate the instrument. The adjustable slide is made from a 3.8 cm (1.5 in) PVC pipe coupling. The coupling has a circular partition inside the coupling where two pipes are normally joined. Remove this partition by sanding it flat with the inner surface of the coupling. The coupling is then fitted to the top of the sampling pipe body (after removing the top endcap). Some sanding and fitting will be required until the inside diameter of the coupling is slightly larger than the pipe body, allowing the coupling to slide over the PVC pipe and mylar-coated measuring tape without binding.

When the sliding coupling is completed, attach a 2.54

cm (1.0 in) width of brightly colored vinyl tape around the center of the coupling. Use of contrasting colors for the adjustable bands will allow easy alignment. In addition, if multiple adjustable slides are used, different tape colors should be used for different circular plot dimensions.

## RESULTS AND DISCUSSION

The circular plot sampling instrument described above has been directly compared with the use of a chain and pin and optical tape measure methods of establishing circular plots in the field. In deciduous forest vegetation areas the circular plot sampling instrument is 8 to 14 minutes faster than the chain and pin method, and from 1.5 to 6 minutes faster per sampling station than the optical tape measure method. Similar sampling efficiencies should be attainable in other vegetation types and these efficiency studies are being conducted at the present time.

In addition to its designed function, the circular plot sampling instrument can also serve as a carrier for folding quadrat frames, wire flags, timber hypsometers, marker lath, maps, and aerial photographs or other items that fit inside the pipe body. The time invested constructing the instrument should be amply rewarded by a reduction in the time needed to conduct a vegetation survey when using the instrument.

## LITERATURE CITED

- Avery, T. 1975 *Natural Resources Measurements* (Second Edition). McGraw-Hill, New York, NY. 339 pp.
- Baker, R. L. and H. A. Pearson 1981 Plot delineation with a pin-and-chain. *Jour. Range Mgmt.* 34: 336-337.
- Barbour, M. G., J. H. Burk, and W. D. Pitts 1987 *Terrestrial Plant Ecology* (Second Edition). The Benjamin/Cummings Publishing Company, Inc. Menlo Park, CA. 634 pp.
- Bitterlich, W. 1948 Die Winkel Zahlprobe. *Allgemeine Forst und Holzwirtschaftliche Zeitung.* 58: 4-5.
- Brown, J. K. 1974 *Handbook for inventorying downed woody material.* U.S.D.A. Forest Service General Technical Report INT-16. Intermountain Forest & Range Experiment Station, Ogden, UT. 24 pp.
- Cain, S. A. and G. M. Castro 1971 *Manual of Vegetation Analysis* (facsimile of the 1959 edition). Hafner Publishing Company, New York, NY. 325 pp.
- Chambers, J. C. and R. W. Brown 1983 *Methods for Vegetation Sampling and Analysis on Revegetated Mined Lands.* U.S.D.A. Forest Service General Technical Report INT-151, Intermountain Forest & Range Experiment Station, Ogden, UT. 57 pp.
- Freese, F. 1962 *Elementary Forest Sampling.* U.S. Forest Service, Southern Forest Experiment Station Agriculture Handbook No. 232. 91 pp.
- Grosenbaugh, L. R. 1952 Plotless timber estimates, new, fast, easy. *Jour. For.* 50: 32-37.
- Hays, R. L., C. Summers, and W. Seitz 1981 *Estimating Wildlife Habitat Variables.* U.S. Fish and Wildlife Service FWS/OBS-81/47. 111 pp.
- Hovind, H. J. and C. E. Rieck 1970 *Basal Area and Point-Sampling Interpretation and Application* (Revised Edition). Department of Natural Resources, Madison, WI. Technical Bulletin Number 23. 51 pp.
- Korhonen, J. 1979 One-person circular plot establishment. *For. Chron.* 55: 51-53.
- Lemmon, P. E. 1958 Aids for using wedge prism. *Jour. of For.* 56: 767-768.
- Mueller-Dombois, D. and H. Ellenberg 1974 *Aims and Methods of Vegetation Ecology.* John Wiley and Sons, New York, NY. 547 pp.
- Nyland, R. D. and K. E. Remele 1975 Prism measures distance for plot boundaries. State Univ. of New York, Applied Forest Res. Inst. Res. Note 17. 4 pp.
- Phillips, E. A. 1959 *Methods of Vegetation Study.* Holt Reinhart and Winston, Inc., New York, NY. pp. 38-45.
- White, W. E. and C. E. Lewis 1982 Establishing circular plot boundaries with a wedge prism and an adjustable target pole. *Jour. Range Mgmt.* 35: 677-678.