

Technical Note

A Laser Point Frame to Measure Cover

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Abstract

The point sample method has been a standard plotless method for measurement of ground cover on rangelands since it was introduced by Levy in 1927. The instrument most commonly used to do point sampling is the point frame. Since its introduction, the point frame has undergone numerous modifications to improve efficiency and ease of use. This article introduces a laser point frame (LPF) that was designed by the Agricultural Research Service for measurement of ground cover and utilizes lasers in place of conventional metal pins. A comparative pilot study was conducted on a shortgrass prairie in northern Colorado to compare data collected using a magnetic point frame (MPF) with data collected using the LPF. Cover by species was measured from identical plots using 100 points per plot for each point frame, and sampling times were recorded for each plot. Correlations between cover data collected using the MPF and the LPF were relatively high ($r^2 = 0.62\text{--}0.81$). Total average vegetative cover measured with the MPF was 35%, compared with 40%, using the LPF. Cover of total grasses, C₄ grasses, C₃ grasses, and litter, were significantly greater with the LPF method. Total sampling time per 100 points was almost half using the LPF compared with the MPF. The LPF was easy to use, efficient for measurement of cover, and is a potential replacement for conventional point frames.

Resumen

Desde que fue introducido por Levy en 1927, el muestreo de puntos ha sido un método sin parcela estándar para la medición de la cobertura del suelo en pastizales. El instrumento más comúnmente utilizado para coleccionar las muestras es el marco de puntos, el que desde su introducción ha sufrido varias modificaciones para mejorar su eficiencia y facilitar su uso. Este artículo introduce un marco de puntos láser (LPF) que fue diseñado por el Servicio de Investigación Agrícola para medir la cobertura del suelo y utiliza rayos láser en lugar de las agujas metálicas convencionales. Un estudio piloto comparativo se condujo en un pastizal de zacates cortos del norte de Colorado para comparar los datos coleccionados usando un marco de puntos magnético (MPF) con los datos coleccionados usando el LPF. La cobertura por especies fue medida en parcelas idénticas usando 100 puntos por parcela para cada marco de puntos y los tiempos de muestreo se registraron para cada parcela. Las correlaciones entre los datos de cobertura coleccionados usando el MPF y LPF fueron relativamente altas ($r^2 = 0.67\text{--}0.81$). La cobertura vegetativa total promedio medida con el MPF fue 35% comparada con 40% usando el LPF. La cobertura total de zacates C₄, zacates C₃ y mantillo fueron significativamente mayores con el método de LPF. El tiempo total de muestreo por cada 100 puntos con el LPF fue casi la mitad del necesitado con el MPF. El LPF fue fácil de usar, fue eficiente para las mediciones de cobertura y es un reemplazo potencial de los marcos de puntos convencionales.

Key Words: bare ground measurement, magnetic point frame, pin frame, point sampling

INTRODUCTION

Point sampling of vegetation was first introduced by Levy (1927) and Levy and Madden (1933) in New Zealand. This plotless method remains a common method to measure ground cover and species composition on rangelands (Mueller-Dombois and Ellenberg 1974; Cook and Stubbendieck 1986). Bonham (1989) writes that the philosophy behind point sampling is that when "... an infinite number of points are placed in a two-dimensional area, exact cover of a plant can be determined by counting the number of points that hit a plant."

The point frame is the instrument most commonly used to collect point data. Since its introduction, the point frame design has been modified numerous times. Early modifications involved the addition of leather brakes (Heady and Rader 1958), spring brakes (Smith 1959), or magnetic brakes (Conrad 1969; Neal et al. 1969) to control pin movement. Additional modifications reduced frame weight and varied frame support, such as a hinged three-legged frame (Sharrow and Tober 1979). The use of a single pin that is moved after each contact point is recorded and use of notches instead of guide holes were suggested by Rader and Ratliff (1962) and Neal et al. (1969). The addition of a wheel for measuring distances was also proposed (Nerney 1960). Although each modification has proven to have some useful purposes, none have addressed the replacement of metal pins. Metal pins used in point sampling have long been identified as an instrument weakness because they tend to bend, rust, and become blunt (Heady and Rader 1958; Smith 1959;

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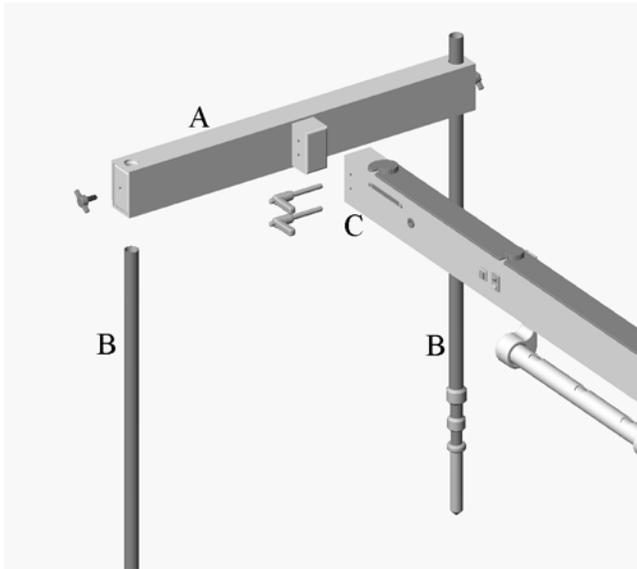


Figure 1. Schematic diagram illustrating the 3 main components used to assemble the laser point frame: **A**, T-bar. **B**, Telescoping legs, 2 of 3 shown. **C**, Main tube. Also shown from left to right on the main tube are quick-release pins for T-bar attachment, voltage monitor panel, battery-charger jack, voltage-monitor button, on/off rocker switch, and handle.

Conrad 1969; Sharrow and Tober 1979; Taha et al. 1983). This article introduces a laser point frame (LPF) that utilizes 10 laser diodes in place of metal pins and compares cover measurements obtained with the LPF and a conventional magnetic point frame (MPF). The objective of this study was to measure the correlation between data obtained from the same plots using the laser and magnetic point frames.

MATERIALS AND METHODS

Laser Point Frame

The laser point frame was constructed from anodized aluminum alloy and was composed of 3 main components: a) T-bar, b) telescoping legs, and c) main tube (Fig. 1). The T-bar component



Figure 2. Photograph of the fully assembled laser point frame used to measure cover on a shortgrass prairie.



Figure 3. Laser point or dot on vegetation and bare ground. Note halo and center of dot.

attaches perpendicular to the main tube with quick-release pins and holds the rear 2 legs. Modified commercial trekking poles were used for the legs to provide variable height and maximum collapsibility with minimal weight and are held in place with thumb screws. The main tube is the primary load-bearing portion of the frame. It connects all 3 legs and contains the laser diodes and electrical components, which can be easily accessed by loosening 5 thumb screws and removing the top of the main tube. An on/off rocker switch, voltage panel, and recharge jack are located on the outside of the main tube. The handle is positioned under the main tube, facilitating upside down transport with the legs pointing upward to avoid encountering brush or other obstacles. Fully assembled, the frame weighs 5.3 kg and is 1.3 m long and 62 cm high (Fig. 2). The height can be extended to 1.3 m by extending the detachable telescoping legs. The unassembled frame can fit into a 137-cm \times 38-cm hard case for safe transport and storage.

The laser point frame utilizes 10 lasers equally spaced 10 cm apart in a nadir orientation. The 4 aspects considered for selecting lasers were wavelength, radiant power, voltage, and cost. The selected lasers had a 650-nm wavelength, with a maximum average radiant power of 3.5 mW, an operating voltage of 3–5 VDC. This combination resulted in a red laser dot that could be seen in full sunlight with minimum energy requirements (Fig. 3). The projected laser dot has a 1-mm diameter (0.8-mm² area). The electrical system is a loop configuration that accommodates both alkaline and rechargeable batteries (Ni-Cd and Ni-MH). Fully charged batteries provide over 10 hours of operation time. When rechargeable batteries are used, the batteries can be recharged in the main tube by an external battery charger plugged into the battery-charger jack on the frame. The unit can then be recharged using either a 110-V wall or 12-V automobile receptacle. Full recharge time was 4 hours from a 110-V wall receptacle.

Total cost for research and development of the frame was about \$1,600 (Table 1). Over half of the total cost was for labor that was charged at \$14.25 \cdot h⁻¹. A total of 65 hours of labor were spent on development and construction of the frame, for a total labor cost of \$926. Material costs were \$255 for frame

Table 1. Cost analysis for research and development of the Laser Point Frame used in this study.

Component	Material cost (\$)	Labor cost (\$)	Total cost (\$)
Frame			
Main frame tube	68	170	238
T-bar	17	75	92
Legs	31	75	106
Electronics			
Lasers	450	214	664
Wiring	8	71	79
Battery charger	112	71	183
LED ¹ voltage monitor	9	100	109

¹LED indicates light-emitting diode.

and electrical materials and \$450 for lasers ($\$45 \cdot \text{laser}^{-1}$), for a total materials cost of about \$700.

Study Area

Field testing of the laser point frame was conducted in late May 2003 at the Central Plains Experimental Range (CPER) located 12 km north of Nunn, Colorado, in the northern portion of the shortgrass prairie (lat 40°49'N, long 107°47'W). The average annual precipitation is 320 mm, of which 70% occurs during the growing season from April through August (Hazlett 1998). Soils at the study site are dominated by the Olney–Owlcreek series (CPER Soil Survey 1991, 1993). The Olney fine sandy loam soil is a fine-loamy, mixed, mesic, Ustollic Haplargid, and the Owlcreek fine, sandy loam soil is a fine-loamy, mixed, mesic, Aridic Argiustoll (USDA-NRCS 1982). Vegetation of the study area is dominated by blue grama grass (*Bouteloua gracilis* H.B.K. Lag.), threadleaf sedge (*Carex filifolia* Nuttall.), fringed sagewort (*Artemisia frigida* Willd. Klein), and plains prickly pear cactus (*Opuntia polyacantha* Haw.) (Hazlett 1998).

Sampling Procedures

Cover was measured on 20 randomly selected 1-m² plots with both a MPF and the previously described LPF on each plot. The MPF was 61 cm high and had 10 metal pins with magnetic brakes, and each pin was spaced 10 cm apart and tapered to a 0.7-mm diameter (0.4-mm² area) point. Both frames used a nadir orientation and cover data were collected by placing the LPF and MPF at established 10-cm intervals within each plot. Ten points were recorded at each interval, for a total of 100 samples per plot. Data were collected by recording the first pin or laser contact as it intersected the vegetation canopy or soil surface. All contacts were recorded by vegetation species, litter, or bare ground. The initial frame to be used (LPF or MPF) was alternated for each plot. In addition, time required for data collection was recorded for the MPF and LPF on all plots using 2 technicians, 1 who determined contacts while the other recorded contacts.

Statistical Analyses

Correlation analysis was used to evaluate the relationship between MPF and LPF for several categories of cover using

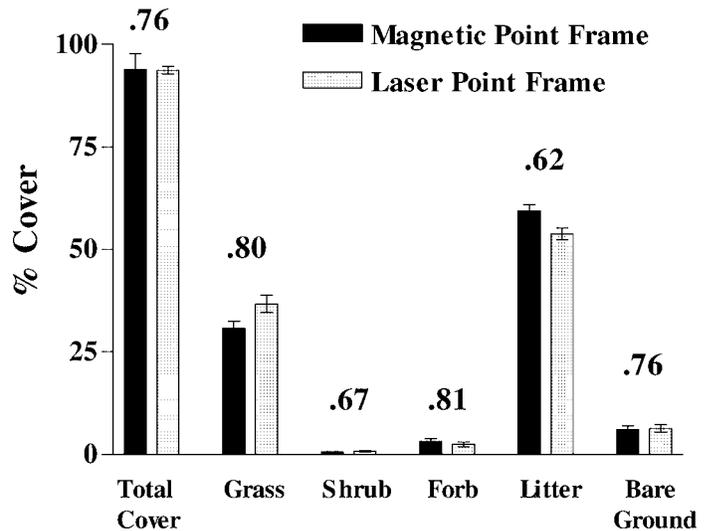


Figure 4. Correlation analysis for the MPF and the LPF by cover category. Correlation coefficients are shown above each pair of bars. Error bars show SD.

a plot-by-plot test for correlation ($n = 20$). Data were also analyzed for differences between means of normally distributed paired sample groups. Each group included mean cover data collected using the MPF compared with similar data collected using the LPF from the same plots. A Shapiro–Wilks test for normality was used to evaluate the homogeneity of variance of each group. Paired t tests were used to test for differences ($P \leq 0.05$) between MPF and LPF cover data for vegetation or soil surface categories (SAS 2001). The mean total vegetative cover (%) and sampling time (min/plot) were analyzed for significant differences. In addition, differences among the mean number of contacts for the following categories were analyzed: total grasses and grass-like species, total C₄ grasses, total C₃ grasses and *Carex* spp., total forbs, total shrubs and cactus, bare ground, and litter.

RESULTS AND DISCUSSION

Laser Point Frame Design

LPF assembly and disassembly required less than 5 minutes. The unit was switched off for travel between plots, and the light weight of the unit made travel efficient and easy. The handle position allowed the technician to carry the unit with a fully relaxed and extended arm that reduced fatigue. The use of lasers eliminated the time needed to lower a pin through the canopy and reduced technician fatigue by allowing a more comfortable position to determine sample contacts. The battery life was adequate for an average 9-hour field day and no problems with the LPF were encountered in the field. Laser-contact visibility (footprint) was slightly affected by solar angle and, although it was visible throughout the day, the footprint was most visible before 1000 and after 1500 hours.

Field Sampling

The comparison of MPF and LPF had a correlation coefficient of 0.76 for cover (Fig. 4). Cover measurements may be affected

by the diameter of the contact point (Mueller-Dombois and Ellenberg 1974; Cook and Stubbendieck 1986); therefore, the difference in cover measurements may be, at least partly, attributed to differences in the contact-point diameter for the 2 types of frames used in this study. Paired *t* tests of the number of contacts among cover categories showed that total grasses and grass-like species, total C₄ grasses, total C₃ grasses that included *Carex* spp., and litter were significantly different ($P \leq 0.01$). However, the average difference between the mean number of contacts among all categories using the MPF and the LPF was found to be less than 1.

The average time to sample and record 100 points was 11 minutes using the MPF, compared with 6 minutes using the LPF ($P < 0.001$). These times resulted in a total cost savings of \$1.12 per 100 points sampled (assumed technician wage of $\$14 \cdot \text{h}^{-1}$) when the LPF was used. Others have reported similar time savings for laser point sampling (J. D. Alexander, Synergy Resources Solutions, Inc., 9 April 2005, personal communication and http://www.countgrass.com/docs/SRM_laserpointer2004.pdf).

The USDA-ARS has 4 LPFs, 2 of which have now been used through 3 field seasons in various projects and plant communities. Minor problems have occurred with poor electrical connections preventing 1 or more lasers from coming on, but these have all been repaired in house. To prevent corrosion of battery contacts, batteries should be removed and stored separate from the LPF. After transporting LPFs over rough roads, even when packed in foam-padded carrying cases, battery placement in the main tube should be checked before attempting to operate the device. Laser-point readability is improved when technicians shade the working area using a parasol or other item, particularly if data collection occurs through midday.

CONCLUSIONS

The LPF was easy and efficient to use for cover measurements on a shortgrass prairie. Correlations between cover data collected using the magnetic point frame and the laser point frame were relatively high ($r = 0.62\text{--}0.81$). Measurements obtained using the MPF were 5% lower than measurements obtained from the LPF. This difference may reflect the respective contact-point areas of the MPF and LPF. If a suitable laser with a smaller contact point becomes available, we recommend it be tested for increasing the LPF accuracy. The LPF saved an average 5 minutes per 100 points of technician time and, in our experience, reduced fatigue.

We conclude that the use of the LPF has the potential to reduce the cost of collecting ground-cover data on a shortgrass prairie and in other plant communities. However, we recom-

mend further testing to confirm the apparent LPF advantage and to further assess the relative accuracy of the LPF with conventional methods.

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