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Tools and Technology Note

A Comparison of Cover Pole With Standard Vegetation Monitoring Methods

DAVID TOLEDO P.,[1,2] *United States Department of Agriculture–Agricultural Research Service, Jornada Experimental Range, and Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003, USA*

JEFFREY E. HERRICK, *United States Department of Agriculture–Agricultural Research Service, Jornada Experimental Range, Las Cruces, NM 88003, USA*

LAURIE B. ABBOTT, *Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003, USA*

ABSTRACT The ability of resource managers to make informed decisions regarding wildlife habitat could be improved with the use of existing data sets and the use of cost-effective, standardized methods to simultaneously quantify vertical and horizontal cover. We characterized vegetation structure of 3 semiarid plant communities to compare cover pole measurements, standard measurements of vegetation cover, composition, height, and the proportion of the soil surface exposed by large intercanopy gaps. We propose that a more versatile and interpretable description of wildlife habitat can be generated using a line-point intercept method together with measurements of vegetation height and the proportion of the soil surface exposed by large intercanopy gaps.

KEY WORDS assessment, gap intercept, habitat quality, monitoring, visual obstruction, wildlife habitat.

Methods, measurement tools, and measurement criteria for assessing vertical cover vary between studies (Toledo et al. 2008). Various cover pole techniques have been used to estimate standing crop (Robel et al. 1970, Harmoney et al. 1997, Benkobi et al. 2000, Vermeire and Gillen 2001), vertical cover, and vegetation structure (Wight 1939, Griffith and Youtie 1988). Few of these results derived from cover pole techniques can be compared because of differences in measurement techniques. Furthermore, many standardized transect-based vegetation monitoring data collected to address other objectives are not currently used to assess and monitor wildlife habitat quality. These data sets represent potentially valuable information for wildlife scientists and managers. Relationships between measurements and variables could prove useful in designing more efficient monitoring protocols that avoid redundancy, optimize sampling effort, and increase cost effectiveness.

Our objectives were to 1) compare a traditional vegetation measurement method used in wildlife habitat analysis (cover pole or Robel pole) and standard measurements of vegetation (canopy cover, composition, height, and proportion of the soil surface exposed by large intercanopy gaps) for their ability to characterize vegetation of 3 semiarid plant communities, 2) use that information to define types and amounts of habitat structure information that can be derived from those standard measurements, and 3) determine the extent to which those data can be substituted for cover pole data.

STUDY AREA

Transects were located in 3 vegetation types in New Mexico, USA, representative of the vegetation structure in most arid and semiarid ecosystems throughout the world: shrub-invaded grassland, shrubland, and piñon–juniper savanna. We selected these study sites to maximize variability of vegetation structural attributes and species diversity both within and among each vegetation community. The shrub-invaded grassland was located on the United States Department of Agriculture Agricultural Research Service Jornada Experimental Range, and the shrubland was located on New Mexico State University's Chihuahuan Desert Rangeland Research Center, both located in Doña Ana County, New Mexico. Mean annual temperature at both of these sites was 16° C, and mean annual precipitation was 245 mm, with >50% of annual rainfall occurring between 1 July and 30 September (Malm 1994). The piñon–juniper savanna site was located on 4 private ranches within a 26-km radius in east-central New Mexico. The area had a mean annual temperature of 11° C and an average annual precipitation of 391 mm (Western Regional Climate Center 2009).

The shrub-invaded grassland site was dominated by black grama (*Bouteloua eriopoda*) with scattered honey mesquite (*Prosopis glandulosa*). The shrubland site was dominated by creosote bush (*Larrea tridentata*), and the savanna site was dominated by piñon pine (*Pinus edulis*), one-seed juniper (*Juniperus monosperma*), and blue grama (*Bouteloua gracilis*). A wide range of vegetation cover existed on these sites because of previous studies in which vegetation composition and structure was experimentally manipulated by removing different groups of species between 1984 and 1995 (Buonopane et al. 2005), including removal of all shrubs from half of the shrub-invaded grassland plots.

METHODS

We measured vegetation composition and structure from June 2003 through November 2003. We conducted sampling at each individual site within 1 month during

[1] *E-mail: david_toledo@tamu.edu*
[2] *Present address: Department of Ecosystem Science and Management, Texas A&M University, College Station, TX 77843, USA*

the same period. We collected data during a drought, which made vegetation changes minimal at the site level. Additionally, for each transect, we completed all measurements on the same day so temporal variability was not an influencing factor.

The shrub-invaded grassland site included 54 transects that were 50 m in length. At the shrubland site, we measured 48 transect sets of 3–15 m transects (i.e., one 45-m transect); transect length at this site was limited because of the plot size of the original vegetation manipulations. We randomly selected transects in the shrub-invaded grassland and shrubland from a set of permanent transects previously established on these sites. The savanna site included 86 50-m transects, randomly located throughout the 4 ranches in central New Mexico, representing a wide range of piñon–juniper cover, including some areas where trees had been killed by herbicide during the 1980s. We recorded time required to perform each method at each site.

We measured visual obstruction (VO) using a cover pole (a modified Robel pole) that was 2 m tall by 2.54 cm in diameter. We divided the cover pole into 4 50-cm segments as described in Bello et al. (2001): we painted each 50-cm segment with alternating 10-cm white and black bands. We distinguished segments by painting the fifth band red. Within each 50-cm segment, we numbered black and white bands 1–5 starting at the bottom of the pole (Toledo et al. 2008). We took VO measurements from a height of 1.5 m using a sight pole placed 7 m from the cover pole (Harrell and Fuhlendorf 2002); for each placement of the cover pole, we took 2 measurements from opposite directions along the tape. We took 6 cover pole measurements (3 placements) on each transect at predetermined locations along the transect. We recorded the number of bands in which $\geq$25% was obstructed by vegetation for each 50-cm pole segment.

We measured canopy cover and height using techniques described in Herrick et al. (2005) and Elzinga et al. (1998). We recorded line-point intercept at 0.5-m intervals along each transect by dropping a pin flag to the ground so that it fell precisely vertically (Elzinga et al. 1998). We recorded vegetation canopy intersecting the pin and material covering the ground surface (Herrick et al. 2005). We measured vegetation height to the nearest 5 cm at 1-m intervals along each transect using a 1.5-m rod, which was marked with alternating colors every 5 cm, or a tape measure if the vegetation was taller than we could effectively measure with the rod. We measured vegetation height at 2 scales. At 1-m intervals, we recorded the maximum height of vegetation intersecting the transect within a 10-cm segment and within a 20-cm segment of the tape. We recorded vegetation height as >2 m when it was taller than 2 m, and we recorded height as zero when no vegetation was present within these segments.

We measured canopy gap intercept along each transect by recording the beginning and end of each gap between plant canopies longer than 20 cm as suggested in Herrick et al. (2005). We ignored plant canopy elements covering <50% of any 3-cm segment of the edge of the tape and considered them part of the gap.

We used transect averages for all variables in all analyses. We determined VO at 2 levels of precision: whole-pole VO and within-segment VO. We determined whole-pole VO by counting the total number of 10-cm bands for which $\geq$25% of the band was covered by vegetation (Griffith and Youtie 1988) and dividing by 20 (total no. of bands/pole). We determined within-segment VO by counting the number of bands within each 50-cm segment in which $\geq$25% of the band was covered by vegetation and dividing by 5 (total no. of bands within each segment). We also used data to calculate 2 height estimates from VO measurements. We determined the lowest visible VO height by recording height of the lowest 10-cm band covered by <25%, and we determined maximum VO height by recording the height of the topmost 10-cm band covered by >25% by vegetation.

We calculated canopy foliar cover by summing all canopy intercepts and dividing by the total number of points per transect. We calculated vegetation height estimates by averaging height measurements taken at 1-m intervals. We performed a separate analysis to determine how the intensity of vegetation height measurements affected the correlation with VO. We completed this analysis by calculating averages of heights measured at different intervals along the transect and correlating them with VO data. For canopy gap intercept, we calculated the percentage of the line exposed in canopy gaps of 25−50 cm, 51−100 cm, 101−200 cm, and >200 cm.

We generated correlations between variables using SAS PROC CORR (SAS Institute, Cary, NC) to characterize the pattern of relationships among variables. We analyzed data from the different vegetation communities both separately and pooled to allow analysis that incorporated a wide range of vegetation structural values. We considered correlations strong where $r > 0.69$ (Fowler et al. 1998).

RESULTS

Visual obstruction and vegetation height were positively correlated at all sites. Whole-pole VO was strongly correlated with the average vegetation height measured at point intercepts for the 3 communities pooled ($r = 0.89$) and for the shrubland ($r = 0.72$) and savanna ($r = 0.83$) sites when analyzed independently, but whole-pole VO was weakly correlated at the shrub-invaded grassland site ($r = 0.51$). Gap intercept variables were not correlated with VO at the shrub-invaded grassland, the shrubland, or the savanna sites.

At the shrub-invaded grassland and shrubland sites, where vegetation height was lower, most VO occurred within the lowest 2 50-cm segments, whereas at the savanna site, the only site with trees, VO was distributed throughout the cover pole (Table 1). Horizontal distribution of vegetation also varied among the sites, with >67% of the soil surface exposed in large (>200-cm), intercanopy gaps at the shrubland site, compared with only 25% at the shrub-invaded grassland site, despite the canopy cover being virtually identical (Table 1). The proportion of the soil surface exposed by these large gaps was lowest at the savanna site (17.3%).

Table 1. Variables calculated from data collected June 2003 through November 2003, for cover-pole visual obstruction (VO), height, line-point intercept, and gap intercept at a New Mexico, USA, shrub-invaded grassland in the United States Department of Agriculture–Agricultural Research Service, Jornada Experimental Range; a shrubland at New Mexico State University's Chihuahuan Desert Rangeland Research Center; and a savanna site located on 4 private ranches within a 26-km radius in east-central New Mexico. Values are mean and standard deviation.

	Shrub-invaded grassland		Shrubland		Savanna	
Variable and site	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Cover pole						
% whole-pole VO (0–2 m)	5.2	5.2	21.4	7.2	36.8	21.5
% VO segment 1 (0–50 cm)	17.3	13.2	16.1	5.7	41.1	19.6
% VO segment 2 (50–100 cm)	2.0	5.5	9.1	5.9	36.2	23.6
% VO segment 3 (100–150 cm)	0.9	3.5	2.9	2.9	35.1	24.5
% VO segment 4 (150–200 cm)	0.5	2.5	0.3	1.0	33.8	24.8
Max. VO ht (cm)	11.3	11.6	52.1	24.1	89.3	49.5
Lowest visible band VO ht (cm)	9.5	8.9	34.0	18.6	51.9	35.9
Ht (cm)						
Ht (cm) at ±5 cm	6.8	3.3	18.3	6.7	47.5	26.2
Ht (cm) at ±10 cm	8.4	3.7	21.6	7.2	50.4	25.9
Line-point intercept (%)						
Canopy cover	27.3	7.9	27.7	6.8	46.3	13.6
Tree cover	0.0	0.0	0.0	0.0	22.5	14.9
Shrub cover	5.8	3.8	12.8	6.4	3.5	7.7
Grass cover	9.0	8.2	1.0	1.6	19.7	13.2
Forb cover	12.4	5.4	13.9	7.9	1.6	2.1
Gap intercept (%)						
Canopy gaps 25–50 cm	8.5	3.4	1.7	1.4	9.2	6.3
Canopy gaps 51–100 cm	17.4	6.4	4.1	2.6	13.5	6.3
Canopy gaps 101–200 cm	27.3	6.7	12.3	8.4	16.7	9.0
Canopy gaps >25 cm	78.1	7.5	85.7	6.3	56.2	16.1
Canopy gaps >50 cm	69.7	9.7	83.9	6.5	47.0	19.6
Canopy gaps >100 cm	52.3	13.6	79.6	7.2	33.9	20.2
Canopy gaps >200 cm	25.0	14.0	67.4	13.0	17.3	16.1

Vegetation height measurements were less time-consuming than cover pole measurements. Additionally, height measurements can be taken while collecting line-point intercept data, reducing the need for a separate method setup and an additional person to hold the cover pole apparatus in place. The average time it took to measure the line-point intercept combined with 10 height measurements was 16 minutes per transect, and the average time it took to measure line-point intercept combined with cover pole measurements was 24 minutes per transect. The time it took to complete the vegetation height measurements was affected by measurement intensity, and height measurement intensity affected correlations with VO (Fig. 1). Although correlation coefficients decreased with incremental reduction in measurement intensity, there was little difference in correlation coefficients between measuring height at every point (50 measurements/transect) and at every fifth point (10 measurements/transect) at the shrubland and savanna sites and at every fourth point (12 measurements/transect) at the shrub-invaded grassland site.

DISCUSSION

Standard vegetation height measurements can substitute for more time-consuming cover pole measurements. The moderate to strong correlation between cover pole variables and vegetation height across all 3 types of plant communities support earlier work on shrublands showing that many vegetation-structure variables are redundant with vegetation height (Harrell and Fuhlendorf 2002). The addition of 10 height measurements on a 50-m line-point intercept transect can provide general information on vertical structure that is correlated with that provided by cover poles in plant communities where cover from the soil surface to the top of the canopy is continuous (Fig. 1).

Both the cover pole methods and the line-point intercept and height methods provided some information about vegetation structure at all 3 sites, but each had limitations. Within-segment VO readings generated information about specific vertical vegetation strata that could not be obtained

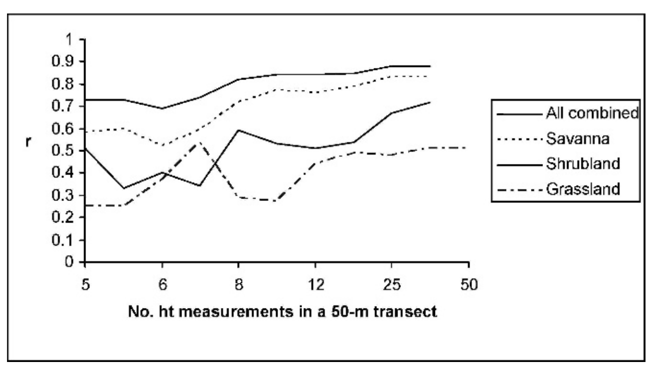

Figure 1. Relationship among correlation coefficients of vegetation height within a 10-cm segment versus whole-pole visual obstruction and vegetation height measurement intensity in a New Mexico, USA, shrub-invaded grassland, shrubland, and piñon–juniper savanna. Sampling was conducted during June 2003 through November 2003.

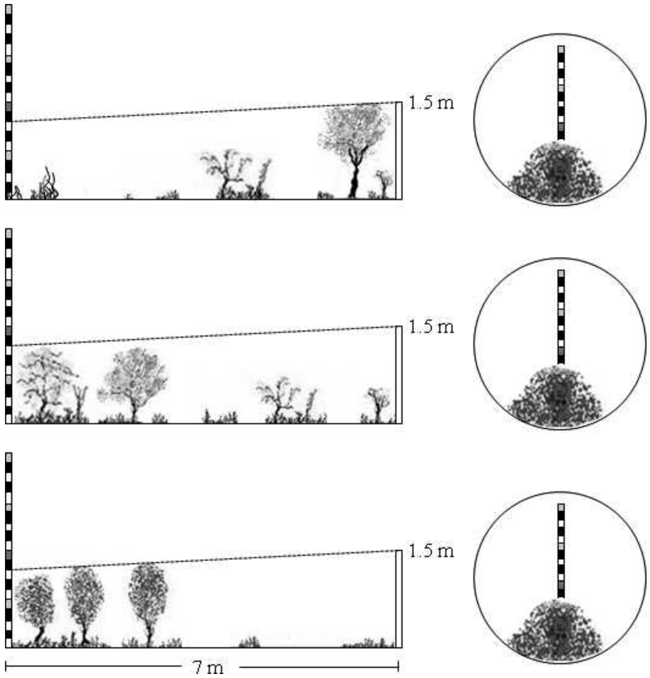

Figure 2. Three vegetation structure patterns in which visual obstruction measurements would yield an identical result without revealing the differences in the vertical or horizontal distribution of the vegetation. These structural differences could be quantified by a combination of line-point intercept, gap intercept, and vegetation height data.

from average vegetation height measurements. However, that approach failed to account for horizontal distribution of vegetation (Fig. 2), as reflected by the lack of correlation between intercanopy gap measurements and VO.

Visual obstruction methods suffer from a lack of standardization and repeatability. Great variability exists in the apparatus used to measure visual obstruction, the manner in which visual obstruction is measured, and in the interpretation of data collected (Toledo et al. 2008). Although cover pole measurements can be adapted to increase their sensitivity to particular plant communities, there is no single combination of cover pole characteristics, observation height, and observation distance that works well for all plant communities. Line-point intercept, gap, and height measurements combined can be consistently applied across nearly all grassland, shrubland, and savanna ecosystems and can be adapted to a variety of monitoring objectives (Godinez-Alvarez et al. 2009). A limitation of both the cover pole and the vegetation height measurement approaches is that, when used alone, they fail to account for differences in the horizontal structure of the vegetation. Both measurements evaluate cover from the eye-level perspective of an upright human and ignore the potential importance of microclimate or hiding cover from avian predators, both of which are related to vegetation spatial structure (Oke 1978, Wiens 1989).

In summary, neither the cover pole nor the height method alone provides enough information to accurately describe vegetation structure. Line-point intercept provides measurements of the percentage of cover by different vegetation functional and structural groups. When combined with height and intercanopy gap measurements, the line-point method can provide a more versatile and broadly interpretable representation of both vertical and horizontal cover than either the cover pole or height and cover measurements alone. Additionally, data collected using the line-point, gap, and height methods are widely available and could easily be reinterpreted for wildlife management purposes.

Management Implications

The addition of height measurements to intercanopy gap and line-point intercept measurements can potentially increase the value of rangeland monitoring for wildlife habitat managers by maximizing the amount of information derived from this standard measurement and by minimizing the number of measurements needed to make informed decisions. These methods can all be used to quantitatively estimate site and vegetation attributes for wildlife habitat evaluation procedures. There are 2 main advantages to adding height measurements at a subset of points on point-intercept transects instead of adding cover pole methods: 1) increased efficiency by minimizing the number of separate measurements and equipment, and 2) increased data consistency, allowing rangeland and wildlife habitat managers to access and integrate multiple data sets.

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