View Point

# Critical Evaluations of Vegetation Cover Measurement Techniques: A Response to Thacker et al. (2015)

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## On The Ground

- Method comparison studies are necessary to reconcile monitoring methods that have arisen among disparate programs; however, we find that Thacker et al.s study comparing Daubenmire frame (DF) and line-point intercept (LPI) methods for estimating vegetation cover is not adequate to support their conclusions.
- Because the DF and LPI methods estimate different aspects of vegetation cover (total canopy vs. foliar cover), there should be no *a priori* expectation that the two techniques would produce the same results.
- Thacker et al. omit critical information about their methods (sampling design, training and calibration, indicator calculations) that could have a large impact on their results and how they can be interpreted.
- Differences in results between different vegetation cover measurement techniques can also be attributable to factors like observer training and calibration, plot heterogeneity and complexity, spatial distribution of vegetation, plant morphology, and plot size; thus it is difficult to draw strong conclusions from a single study.
- Rather than implementing both DF and LPI techniques in sage-grouse studies as Thacker et al. recommend, effort should instead be invested in ensuring that sampling for one selected method is adequate.
- Critical evaluations of vegetation measurement methods to advance the science of rangeland monitoring should be conducted and reported in a rigorous manner, provide a thorough review of previous studies, and discuss how new results contribute to existing knowledge.


**Keywords:** monitoring, rangeland management, canopy cover, foliar cover, method comparison, sage grouse, *Centrocercus urophasianus*.

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Successfully managing and restoring rangelands, including mitigating impacts of land uses and adapting to changing climates, requires information on the condition and trend of rangeland ecosystems. Coordinated monitoring efforts across land uses and land management agencies are paramount to achieving this. Thus it is necessary to reconcile monitoring methods that have arisen among disparate programs, especially when assessing and monitoring habitat for landscape species like greater sage-grouse (*Centrocercus urophasianus*). In this spirit, we welcome the comparison Thacker et al.[1] make between line-point intercept (LPI) and a Daubenmire-frame (DF) technique for estimating vegetation cover in sagebrush (*Artemisia* spp.) systems. However, we find Thacker et al.'s descriptions of their methods, analysis and results, and discussion are incomplete and cannot support their conclusions that 1) cover estimates from DF and LPI methods are incomparable; and 2) both DF and LPI methods should be conducted when assessing or monitoring sage-grouse habitat.

## Defining Cover: the Devil is in the Details

Thacker et al.[1] claim that the DF and LPI methods "… are commonly used to estimate the same vegetation parameters (percent of canopy cover)…" (p7) and ask the question, "Are they [estimates from the two methods] the same?" (p9). However, their claim that these two methods estimate the same vegetation parameter is technically incorrect.

While LPI and DF both are methods for estimating cover, they differ in their definition of what constitutes cover, and hence do not estimate the same thing (Fig. 1). The LPI technique provides estimates of foliar cover[i], whereas the DF

[i] While LPI is most commonly used to estimate foliar cover, it can be implemented to estimate canopy cover by modifying the definition of what constitutes a "hit" to include any vegetation or void within the zone of influence of the plant.[2] However, this is not a common implementation of the LPI technique.

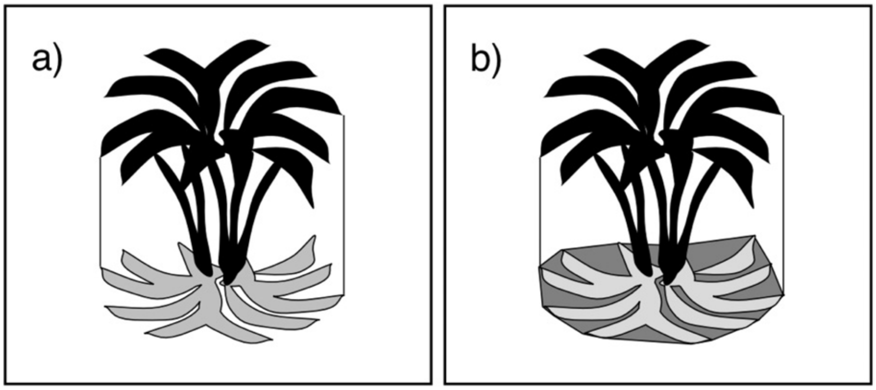


**Figure 1.** a, Foliar cover is the area of ground covered by the vertical projection of the aerial portions of the plants and measures just the exposed plant area. b, Alternatively, canopy cover is the area of ground covered by the vertical projection of the outermost perimeter of the natural spread of foliage of plants (small voids within the canopy are included) and measures the area of influence of the plant. Reprinted from Figures 6 and 7 in Coulloudon et al.[3]

technique produces estimates of canopy cover.[3,4] The Society for Range Management Glossary[5] defines foliar cover as "the percentage of ground covered by the vertical projection of the aerial portion of plants" where "small openings in the canopy and intraspecific overlap are excluded." Canopy cover is defined as "the percentage of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants" where "small openings within the canopy are included". This usage is consistent with descriptions and protocols of the two techniques used by the Bureau of Land Management, Forest Service, and Natural Resources Conservation Service.[3,6,7]

Habitat suitability ranges for sage grouse in terms of cover of sagebrush, and cover of perennial grasses and forbs were developed from studies that used the definition of total canopy cover.[8] However, habitat suitability classes for vegetation cover indicators are broad, with the requirement for suitability of that indicator being only that the measured values fall within the defined range. Additionally, overall habitat suitability for sage grouse is determined by experts assessing a suite of indicators, one of which is vegetation cover.[9] Thus, assessments of sage-grouse habitat suitability are designed to be robust to imprecisions in indicator measurements caused by observer variability or different methods. The Sage-Grouse Habitat Assessment Framework[9] concludes that both DF and LPI are appropriate for assessing sage-grouse habitat and states, "Since transect data are averaged and suitability classes are relatively broad, the differences between techniques used to arrive at those estimates should have minimal impact on the end result." However, this is an assumption that Thacker et al. attempted to test.

Ultimately though, because the two methods are estimating different aspects of vegetation cover, there should be no a priori expectation that the LPI and DF techniques would necessarily produce the same results for the same sample area. Because of this, the important questions when comparing the two techniques should revolve not around whether the LPI and DF methods yield the same result, but what vegetation characteristics contribute to differences, whether a relationship can be defined between the LPI and DF methods, the relative accuracy and precision of the two methods, and the implications of the differences to assessing sage-grouse habitat or making management decisions under different scenarios.

Additionally, the results from a comparison study in a single site may not be generalizable to other sites or systems. For example, an assumption of the DF technique using cover classes is that mean cover within each class approaches the class mid-point. If actual species or functional group cover does not approach the class mid-point, then the DF technique can produce biased cover estimates. Hence the result of comparing DF cover estimates with those from another method like LPI may be system dependent.

## Protocols and Indicators

To compare two techniques adequate information must be provided on how the techniques were implemented and indicators computed. Martyn et al.[10] showed within-plot DF sampling by Thacker et al.[1] may have been inadequate and accounted for observed differences between the two methods. Additionally, Thacker et al. omitted critical information about their methods that could have a large impact on their results and how they can be interpreted.

First, no information was given on how observers were trained and calibrated in the LPI and DF methods. Numerous studies have raised concerns about the potential bias and high inter-observer variability with DF methods.[11–13] Thorough training and calibration is an important part of implementing DF and LPI in an assessment or monitoring program, and in the context of Thacker et al.'s paper, knowledge of how observers were trained and calibrated is necessary to interpreting the results they report. Likewise, information on the number of observers and any evaluation of among-observer variability should be reported.

Second, information on how LPI data were synthesized into functional group indicators is insufficient. Vegetation that intercepted the pin drops in LPI was recorded to species or functional group. But at what point were the species data collapsed into functional groups for calculating the indicators, and how were the different vegetation layers at each pin tallied? For example, if bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) Á. Löve) and Thurber's needlegrass (*Achnatherum thurberianum* (Piper) Barkworth) were both intercepted at a pin drop, was this counted as two hits of the perennial grass functional group, or one functional group hit? Thacker et al. is moot here, but the former would produce LPI cover estimates consistently greater than DF.

## Analysis Techniques for Comparing Techniques

Additionally, we found the analysis and results Thacker et al.[1] presented inadequate to support their conclusions. Discussion is needed of why the results were different and factors that may have led observers to underestimate DF cover relative to LPI. The three functional groups (annual grass, perennial grass, forb) considered in the paper are important for evaluating sage-grouse habitat.[9] However, to fully understand why LPI cover estimates were greater than DF, it is necessary to report results for additional indicators (e.g., shrub cover, bare ground). If the two techniques were unbiased, LPI estimates for shrubs and bare ground should have been less than DF estimates. If LPI estimates are consistently greater across all indicators, that would suggest bias in one method or its implementation. Analyses such as linear regression or limits of agreement[14,15] between the LPI and DF could provide insight on the nature of differences between the methods by quantifying the strength of the relationship, as well as the tendency for systematic differences between methods. This would provide a test for Thacker et al.'s[1] statement that "As cover increased, the mean differences by methods also increased."

Also, Thacker et al.'s[1] interpretation of the mean-difference test to conclude the two methods are not comparable is incorrect. The statistical test performed was that the mean difference between the methods was zero. However, in this result (which was influenced in large part by sample size), the authors confuse statistical significance with management significance. Given their sample, DF and LPI cover indicators were significantly different from each other, but the average difference for annual grasses was less than 4%. Even for the other indicators, the differences between the two methods may be on the order of other sources of sampling error. Because the types of vegetation cover being measured by the two methods are different and a mean-difference of zero cannot be assumed (see above), a more appropriate interpretation of this result would be as a characterization of the average correspondence (or divergence) of the two methods for different indicators.

## Interpreting Results

Thacker et al.[1] also fail to place their study within the context of similar studies, and thus we disagree with the recommendations of this study. Numerous studies have been conducted that explore the accuracy and precision of ocular cover estimation techniques within frames or foliar cover estimation via point-intercept techniques from a theoretical[16,17] or empirical basis.[11,12,18–23] These studies have produced mixed results for several reasons. First, what is being measured as "cover" can be different between techniques and produce different estimates (see above). Second, differences in the results between techniques may be attributable to factors like observer training and calibration, plot heterogeneity and complexity, spatial distribution of vegetation, plant morphology, and plot size. Considering the high degree of variability in results of similar studies, it is difficult to draw strong conclusions solely from Thacker et al.'s[1] study.

The conclusion of Thacker et al.[1]—that, given the reported differences between LPI and DF, both methods should be employed in monitoring—is problematic and could create additional confusion. As previous studies have reported conflicting results in comparing LPI and DF, which estimates should be used when the methods return different results? This could lead to situations where methods are selected subjectively depending on desired result. Given that the reliability of both LPI and DF cover estimates are a function of within-site and among-site sampling efforts, a stronger conclusion would be to pick one method and ensure adequate sampling rather than investing in a second set of measurements.

## Conclusion

Critical evaluations of vegetation measurement methods are a necessary part of advancing the science of rangeland monitoring. However, these studies should be conducted and reported in a rigorous manner, provide a thorough review of previous studies, and discuss how new results contribute to existing knowledge. Additionally, data used in method comparison studies should be made available in public data repositories so that other researchers may investigate and incorporate their data into further method comparison studies. To understand how monitoring methods relate to each other comparison studies must follow and thoroughly describe a rigorous evaluation process, including but not limited to: clearly stated definitions of the indicators being measured, thorough training and calibration of the data collectors, appropriate statistical analysis, and interpretation of results in a broader management and scientific context. Thacker et al.'s[1] study falls short in these respects. Namely, their conclusion that cover estimates from DF and LPI are not comparable is based on a faulty assumption that these techniques measure the same indicator and on an incomplete analysis of their data.

Ultimately, the selection of which method to implement for sage-grouse habitat monitoring should be based on which method best measures functional indicators of habitat quality for a stated objective. Whether or not a method can provide additional (or supplemental) indicators of habitat quality (e.g., abundance of invasive species) should factor in the selection of methods as well. Consideration should also be given to whether or not the data that were collected are to be used for other monitoring purposes, and whether the method employed can reliably produce estimates of other ecosystem attributes like soil and site stability, hydrologic function, and biotic integrity. Rather than implementing both methods in sage-grouse studies as they recommend, that extra effort should instead be invested in ensuring that a single selected method informs appropriately on a suite of relevant habitat indicators and that sampling for that selected method is adequate.

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