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Sound Science White Paper Series #03

Measuring Vegetation with the Line-Point Intercept and Line Intercept Methods

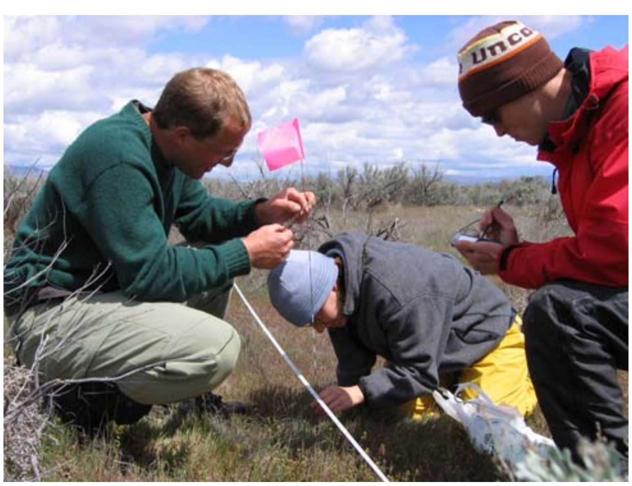
The line point intercept (LPI) and the line intercept methods are rapid and accurate ways to assess vegetation and soil cover. Both methods are easy to learn and give reproducible, unbiased results. These features are important because field crew staffing typically changes over time, introducing undetectable bias that may hide real change in training area condition.

Vegetation and soil cover protect the soil from wind and water erosion, slow water infiltration and overland flow, and reduces evaporation from the soil. The amount and variety of vegetation affects the resistance of a site (that is the ability of a site to *resist* change when disturbed) and its resilience (the site's ability to *recover* after disturbance). Conversely, the amount of bare soil at a site (the absence of either vegetation or soil cover) affects its risk of erosion; increasing bare soil is nearly always a sign of impending soil loss. This White Paper is a primer on using the LPI and line intercept methods and calculating different types of cover.

The Line Point Intercept Method (LPI)

Overview of line-point intercept

The Line-Point Intercept (LPI) method uses a series of locations (points) a set distance apart along a transect (line). The basics of LPI are simple: an observer walks along the transect, drops a pointer at each sampling point, and records information about the vegetation and soil cover at the pointer's location. The attributes evaluated at each point are usually qualitative, involving either yes/no decisions ("Is there a plant here?"; "Is there anything lying on the soil surface?") or categorizing the cover encountered ("What type of plant is it?"; "What material is lying on the soil surface?").



If transects are already being used to collect other data, LPI data may be collected at the same time. If new transects are being established for LPI, one must decide on the number of transects to use and the number of points along each transect. Generally, accuracy increases faster with more transects than with more points per transect. Each transect is often a sample unit (that is the smallest unit that is sampled and on which calculations are made and data are analyzed). A minimum of 50 observations per transect is necessary to estimate cover at increments of 2%.

Alternatively, each point may be treated as a sample unit if sample points are not spatially autocorrelated[1]. In this case sample points on transects should be spaced farther apart than the average-sized plant. This approach is most useful when the area sampled is oddly shaped, making it difficult to lay out many transects of the same length.

Note that while the basics of line-point intercept are the same with all arrangements of transects and points, this White Paper discusses only calculations for cases where the transect is the sample unit. See the White Paper titled "Contingency Tables in Land Stewardship: Evaluating Differences among Categorical Variables" for calculations when each point is the sample unit.

Basics of line-point intercept

Once transects are laid out, one needs a pointer that will identify the exact point on the ground that will be assessed. Pin flags at least 75 cm (2.5 feet) long make excellent pointers and are inexpensive. The 'pin' portion must be as narrow as possible, as the goal is to sample a dimensionless point in space; large diameter pins increase the likelihood of intercepting vegetation. Alternatively, a commercially available laser point sampler (**Figure 1**.) can speed sampling. (see Synergy Resource Solutions, Inc., http://www.countgrass.com). An alternative when using LPI for overhead cover is either a commercially available or a homemade optical sighting device with crosshairs.

Figure 1. Laser point sampler for line-point intercept (photo courtesy J. Alexander).

Although the distance between sampling points on the transect is set in advance, it is not important to aim the laser point sampler or drop the pin flag at that exact point. However, it is critically important that the pointer is aimed or the pin is dropped at a *random* point while *the observer* stands at the sampling point. It is best to look away while placing the pointer or pin, to avoid biasing the sample by influencing where it lands.

[1] Spatial autocorrelation means that adjacent points are more similar than randomly selected pairs of observations. Thus, spatially autocorrelated observations are not independent, a violation of a basic assumption of statistics. Spatially autocorrelation in LPI data indicates that the observation points are close enough that adjacent points are striking the same plant or bare ground patch.

A laser point sampler, physically separated from the upright, and guided straight down by a level, provides less biased and more reproducible results as it is much more difficult for an observer to influence its location than when using a pin flag. When using a pin flag, it is important that it is dropped vertically and from the same height each time, so that each sample is collected in the same manner. **Hint**: walk on only one side of the transect and collect data on the other side to avoid trampling effects.

With the pointer or pin in place, record ‘hits’ -- the vegetation and soil cover intercepted by the device. As these change with the relative positions of the pointer or pin and the vegetation, it is important to hold the pointing device still and move the vegetation at little as possible while working. This makes it very difficult to collect LPI data accurately on windy days, especially in open areas. Pin flags have an advantage over laser point samplers when determining hits, as all layers of intercepted vegetation are easily seen along a pin. Laser point samplers, on the other hand, only intercept the top layer of vegetation. Hits are recorded sequentially from the top, while moving successive layers of vegetation to the side to reveal the next layer.

Limitations of line-point intercept

Vegetation cover is determined by both the number of plants (density) and the size of each plant (production or biomass). Line-point intercept does not differentiate between these two components of cover. In addition, LPI is not appropriate for estimating the abundance of rare species, the early stages of invasions by undesirable plants, or rare events , as the probability of intercepting one at a pointer location is low. Belt transects, walking grids, distance measures, or time-constrained searches are more efficient for monitoring rare events or occurrences.

Cover measurements with line-point intercept

A variety of types of cover can be measured using LPI; the type of cover measured depends on one’s management objective and monitoring goals. In each case, LPI measures the amount and type of vegetation and/or physical cover present to protect the soil from wind and water erosion. The line-point intercept method groups observations into qualitative categories. The most common categories for each type of cover are described here, but categories may be adapted to suit one’s monitoring needs.

Foliar Cover. This is the area of ground with any vegetation directly above it. It is usually expressed as a percent and is one indicator of how well the soil is protected. Foliar cover varies widely within years as plants grow through the season, and among years, as plants grow larger during more favorable years. When monitoring vegetation over multiple years, it is important to measure foliar cover at the same phenological (plant growth) stage each year. Because plant growth stages are reached at slightly different times, due to variations in the weather each year, it is more accurate to monitor at the same plant growth stage each year than on the same date. Examples of plant growth stage include early regrowth of perennials in spring, early bloom for forbs, full bloom, seed set, etc.

Measure foliar cover by recording the species or life form (annual grass, annual forb, perennial grass, perennial forb, shrub, or tree) of each different type of vegetation touching the pin. One plant touching the pin in several places is only recorded once and two plants of the same species or life form are also only recorded once. Note: grass like plants, such as sedges and rushes, are often included with grasses to simplify data collection. As more than one species or life form may intercept the pointing device at a sampling point, total foliar cover can be greater than 100% when the cover of all species or life forms are summed.

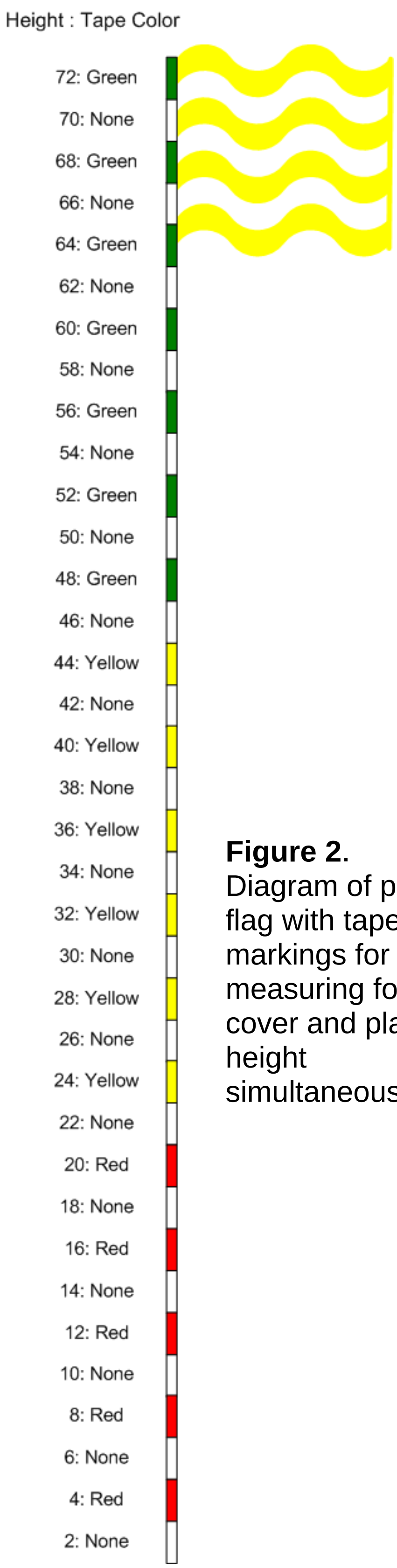


Figure 2. Diagram of pin flag with tape markings for measuring foliar cover and plant height simultaneously.

Foliar Cover with Plant Height. Plant heights can be recorded at the same time as foliar cover if one is using a pin flag as a pointer. Alternating bands of 2 cm-wide colored tape and areas without tape allow heights to be recorded to the nearest 1 cm. Sectioning the pin with different color tape (e.g. red from 0-25 cm, yellow from 25 to 50 cm, etc.) speeds data collection by allowing heights to be read at a glance (**Figure 2**). It is important to use *thin* layers of tape to keep the diameter of the pin as small as possible. Record the tallest point a plant species or life form touches the pin. Vegetation taller than the pin flag can be measured using a telescoping pole with decimeter markings added (tape would interfere with the telescoping action and decimeters are much easier to read at a distance). In addition to adding a measuring scale to the pole, draw a narrow line along the pole and record heights only where vegetation intercepts the line. Note that this method is only appropriate for sites with occasional trees.

Basal Cover. This is the area of ground covered by the rooted areas of plants. It is usually expressed as a percent and is an excellent indicator of how well the soil is protected from sheet erosion. Basal cover varies less with rainfall than foliar cover, both within and among years, making it more suitable for monitoring long-term vegetation trends. This type of cover is most useful in areas dominated by perennial grasses, which have relatively large basal areas (crowns).

Measure basal cover by recording the species or life form of the plant on which the base of the pin is resting or, if using a laser point sampler, the lowest vegetation layer found. As each sampling point will be assigned to one, and only one category, total basal cover cannot sum to over 100% across the sample unit. Note: measuring the gaps between basal areas of perennial species is an excellent way to evaluate not only the amount of vegetation protecting the soil, but also its distribution. This is important as a few large unprotected areas are usually at greater risk of soil erosion than are many small unprotected areas.

For more information on the basal gap intercept method see the Soil Erosion Susceptibility white paper.

Soil Cover. This is the area of soil covered by material that is either lying on its surface or an integral part of it. It is usually expressed as a percent and is an indicator of how well the soil is protected. Measure soil cover by recording the material on which the base of the pin is resting or, if using a laser point sampler, the final layer of material covering the soil. As each sampling point will be assigned to one, and only one category, total soil cover will always sum to 100% across the sample unit.

Categories of soil cover may include, but are not limited to:

- Litter - detached plant material lying on the soil
- Embedded litter - litter that would leave an indentation in the soil if it were moved; may also be included in litter
- Manure - if frequent at the site; may also be included in litter
- Duff - where no clear boundary exists between litter and soil, usually in forested areas
- Woody debris - detached fragments greater than 5 mm (0.25 inch)
- Rock - fragments greater than 5 mm (0.25 inch)
- Bed rock - exposed bed rock
- Basal area of plants - basal area of dead plants may be included, as they offer similar protection to soil
- Biological soil crust - includes moss, lichen, and cyanobacteria. See Further Reading section for link to more information.
- Bare soil - soil without any other material either lying on its surface or an integral part of it

Bare Soil Cover. This is the area of soil without any vegetation or soil cover above it. It is usually expressed as a percent and is the portion of the soil at greatest risk to erosion and disturbance. Measure bare soil cover by recording sampling points where the pin or pointer does not intercept any vegetation *and* the soil cover category is 'bare soil'.

Calculating cover from line-point intercept data

Once vegetation and soil cover data are carefully recorded in the field, one can calculate the appropriate types of cover. This White Paper describes only cases where the transect is the sample unit. See the White Paper "Contingency Tables in Land Stewardship: Evaluating Differences among Categorical Variables" for calculations where each point is the sample unit.

Foliar Cover. Calculate foliar cover of each species or life form by dividing the number of hits (points where the species or life form was intercepted) by the total number of points in the sample unit, then multiplying by 100 to convert to a percent (**Figure 3**). When summed over the sample unit, total foliar cover can be greater than 100%.

Foliar Cover with Plant Height. Calculate average plant height of each species or life form by summing all heights for each species or life form and dividing by the number of points where that species or life form was intercepted in the sample unit (**Figure 3**).

Basal Cover. Calculate basal cover of each species or life form by dividing the number of hits (points where the species or life form was intercepted) by the total number of points in the sample unit, then multiplying by 100 to convert to a percent **(Figure 3)**. Total basal cover will always equal 100% when all types of cover are summed over the sample unit.

Soil Cover. Calculate cover of each soil cover category by dividing the number of hits (points where the category of cover was intercepted) by the total number of points in the sample unit, then multiplying by 100 to convert to a percent (**Figure 3**). Total soil cover will always equal 100% when all types of cover are summed over the sample unit.

Bare Soil Cover. Calculate bare soil cover by dividing the number of points without vegetative *or* soil cover by the total number of point in the sample unit, then multiplying by 100 to convert to a percent (**Figure 3**).

Site: Hart Mt. XT1.04.T2			**Date:** 30 June 2006			**Crew:** EC, CK			**Dist. b/t points:** 1 meter, Hts in cm			**P** _1_ **of** _1_
Point	Sh	Sh ht	PG	PG ht	PF	PF ht	AG	AG ht	AF	AF ht	Soil	Notes
1											Bare	Bare soil
2	ARAR8	10									Bare	Bare soil
3	ARAR8	21	ELEL	36							Bare	
4			POSE	5							Litter	
5											Bare	Bare soil
6											Rock	
7			POSE	4							Rock	
8									LEPE	8	Rock	
9											Rock	
10							BRTE	9			Rock	
11											Bare	Bare soil
12											Basal	
13							BRTE	5			Litter	
14											Rock	
15											BSC	
16							BRTE	14			Rock	
17											Rock	
18											Rock	
19			POSE	23							Basal	
20											Litter	
21											Litter	
22											Rock	
23			ACTH	20							Bare	
24											Rock	
25											Litter	Rabbit scat
26											Basal	
27											Bare	Bare soil
28											Rock	
29									EPBR	10	Bare	
30											Rock	
31											Rock	
32											Rock	
33											Rock	
34											Rock	
35											Rock	
36											Bare	
37											Bare	Bare soil
38											Bare	Bare soil
39											Bare	Bare soil
40			POSE	6							Bare	
41	ARAR8	22									Litter	
42											Bare	
43											BSC	
44	ARAR8	15									Bare	Bare soil
45											Litter	
46					BASE2	6					Bare	
47											Bare	Bare soil
48											Bare	Bare soil
49					ARAC2	3					Rock	
50			POSE	20							Rock	
Height sums:		68		114		9		28		18		

Plant life form

Species codes from USDA PLANTS database http://plants.usda.gov/

Foliar Cover calculations:
Sh = (2/50)*100 = 4%
PG = (7/50)*100 = 14%
PF = (2/50)*100 = 4%
AG = (3/50)*100 = 6%
AF = (2/50)*100 = 4%

In this case total foliar cover is less than 100%; in more humid areas it can be more than 100%.

Soil Cover calculations:
Litter = (7/50)*100 = 14%
Rock = (20/50)*100 = 40%
BSC = (2/50)*100 = 4%
Bare = (18/50)*100 = 36%

This is a very gravelly soil, which protects the soil.

Bare Soil Cover calculations:
(10/50)*100 = 20%

Note that Soil Cover category 'bare' is greater than Bare Soil Cover, as the latter includes only points without vegetative *or* soil cover.

Plant Height calculations:
Sh = (68/4) = 17.0 cm
PG = (114/7) = 16.3 cm
PF = (9/2) = 4.5 cm
AG = (28/3) = 9.3 cm
AF = (18/2) = 9.0 cm

Figure 3. Sample line-point intercept data sheet and calculations for Foliar Cover with Height and Soil Cover.

Layers	Measurement	Definition	Recorded as	Calculation
Plants	Foliar Cover	Area of ground with vegetation above it	Identity of vegetation	Hits in category / Points in sample unit x 100
	Foliar Cover with Plant Height	Height above ground	Highest point where vegetation touches pin	Sum of heights in category / Points in category
	Basal Cover	Area of ground covered by rooted area of plants	Identity of plant base	Hits in category / Points in sample unit x 100
Plants and soil	Bare Soil Cover	Area of soil with no vegetative or soil cover	Absence of either vegetation or soil cover	Number of points / Points in sample unit x 100
Soil	Soil Cover	Area of soil with material lying on surface or part of it	Identity of material on or in soil	Hits in category / Points in sample unit x 100

The Line Intercept Method

Overview of line intercept

The line intercept method also uses a transect (line) to sample vegetation, but this method measures vegetation canopy cover continuously along the line, rather than at discreet points. If transects are already being used to collect LPI data, line intercept data may be collected at the same time. With this method individual transects are a sample unit.

Basics and limitations of line intercept

This method is best suited to measuring plants that have canopies with easily discernable margins. Such plants include shrubs, bunchgrasses (as opposed to rhizomatous grasses that form sod), and large forbs. Line intercept is most commonly used to sample canopy cover of shrubs, as they have the most clearly-defined canopies.

An observer walks along the transect and notes the starting and ending points of segments of plant canopies along one side of the measuring tape. The linear intercept distance of the life form or species of interest can then be calculated. Before collecting data, clearly state rules for starting and ending segments of plant canopies (e.g. how large must a segment be to be counted and how large must a gap in canopy cover be to end a segment?). Workers in relatively arid sagebrush grasslands often use 2 cm to start or end a canopy segment.

When the primary interest is in determining the concealment provided by shrubs, minimum canopy gap lengths can be defined as being 30 cm or more in length. This results in the cover of a shrub being defined as its “area of influence” rather than absolute cover, as gaps within an individual shrub are ignored. This is most useful when working in systems that have large clumps of shrubs with fairly diffuse canopies (e.g., mesquite).

In addition to rapidly and accurately sampling canopy cover, line intercept may also be used to sample the linear distance of visible soil disturbance. In this case, an observer walks along the transect and notes the starting and ending points of segments of visible soil disturbance along one side of the measuring tape.

Measuring the gaps between plant canopies is an excellent way to evaluate not only the amount of canopy cover, but also its distribution. This is important as a few large unprotected areas are usually a greater threat to soil stability than are many small unprotected areas. See the Soil Erosion Susceptibility white paper for more information on the canopy gap intercept method.

Cover measurements and calculations with line intercept

Calculating canopy cover from line intercept data is straight forward: sum the linear intercept distances for all segments of the life form or species of interest, divide by the total length of the sample unit, then multiply by 100 to convert to a percent (**Figure 4**). Cover of visible soil disturbance of different categories is calculated similarly.

$$\frac{\text{Sum of linear distances in category}}{\text{Total length of sample unit}} \times 100$$

Shrub Cover calculations:
Total = (3.24/50)*100 = 6.5%
Live = (3.18/50)*100 = 6.4%
Dead = (0.06/50)*100 = 0.1%

Figure 4. Sample line intercept data sheet and calculations for Shrub Cover.

Site: Hart Mt. XT1.04.T2		**Date:** 30 June 2006	**Trans. Length (m):** 50	**Crew:** EC, CK	**Page** 1 **of** 1
Segment Number	**Species Code**	**Segment Status**	**Segment Start**	**Segment End**	**Segment Length**
1	ARAR8	Live	0	0.37	0.37
2	ARAR8	Live	1.93	2.16	0.23
3	ARAR8	Live	3.13	3.78	0.65
4	ARAR8	Live	17.93	18.31	0.38
5	ARAR8	Live	40.87	41.12	0.25
6	ARAR8	Live	42.32	42.65	0.33
7	ARAR8	Live	42.84	42.97	0.13
8	ARAR8	Live	43.7	44.16	0.46
9	ARAR8	Live	45.52	45.68	0.16
10	ARAR8	Live	46.47	46.69	0.22
11	ARAR8	Dead	47.34	47.4	0.06
12					
13			Total shrub cover:		3.24
17			Live shrubs cover:		3.18
18			Dead shrub cover:		0.06
19					
20					

Further reading:

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Rosentreter, R., M. Bowker, and J. Belnap. 2007. A Field Guide to Biological Soil Crusts of the Western U.S. Drylands. U.S. Government Printing Office, Denver, CO. Available online at: http://sbsc.wr.usgs.gov/products/pdfs/Field_Guide_Book_25.pdf