Technical note: Comparing 4 techniques for estimating desired grass species composition in horse pastures¹

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ABSTRACT: Many methods exist for estimating species composition, but few studies compare those useful in improved horse pastures. The objective of this study was to examine 4 techniques for estimating desirable forage species composition in 2 cool-season horse pastures based on prevalence estimates, repeatability, bias, and practicality, and to select a method for use in a subsequent grazing study. The techniques included Equine Pasture Evaluation Disc (EPED), Line-Point Intercept with 3 transects of 50 observations each (LPI 3–50), LPI with 5 transects of 30 observations each (LPI 5–30), and Step Point (StPt). A generalized linear-mixed effects model procedure of SAS (GLIMMIX) with a logit link was used to test for differences among each species separately. When methods were significantly different ($\alpha = 0.05$), pairwise comparisons were performed using a paired *t*-test. The

methods did not differ in detecting creeping bentgrass ($P = 0.3334$) or orchardgrass ($P = 0.4207$), but there were differences for Kentucky bluegrass ($P = 0.0082$), tall fescue ($P = 0.0314$), and other ($P = 0.0448$). Repeatability plots displayed lower method repeatability as species prevalence increased. Agreement was analyzed between pairs of methods by grass species. Five out of 30 pairs showed significant overall bias ($P = 0.0114, 0.0045, 0.0170, 0.0328$, and 0.0404), and 3 of them were between LPI 3–50 and EPED. The LPI 3–50 and LPI 5–30 techniques agreed perfectly in prevalence and bias, as did StPt and EPED, meaning they can be used interchangeably. The techniques LPI 3–50 and EPED were the most dissimilar methods. In conclusion, StPt can be used interchangeably with LPI, but StPt was selected due to its thorough representation of the pastures and ease of use.

Key words: cool season pasture, Equine Pasture Evaluation Disc, horse pasture, Line-Point Intercept, species composition, step point

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INTRODUCTION

Horses evolved as grazing animals and tend to have fewer health problems when on pasture than when stalled (Bott et al., 2013). They are also

selective grazers, preferring grasses (Olson-Rutz et al., 1996), and show preference among grass species (Allen et al., 2013). This often results in overgrazing of desirable forages and proliferation of weeds, which decreases the pasture's overall nutritional quality (Bott et al., 2013). Therefore, it is important for both farmers and researchers to estimate desired forage species composition to make pasture maintenance decisions, track shifts in forage species over time, estimate pasture productivity and nutrition, and analyze canopy cover to predict the risk of soil erosion (Burk and Taylor, 2010). There are several methods available

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to assess species composition (Herrick et al., 2009a, 2009b). However, methods relevant to temperate cultivated horse pastures have not been compared in terms of species prevalence, repeatability, and agreement.

These methods measure either points, transects, or plots visually or using pins or lasers (Booth et al., 2006). Four techniques of 3 methods were selected for comparison. The Line-Point Intercept method (LPI; Caratti, 2006) is used frequently in rangeland research and is often considered the standard. However, others contend that a limited number of transects cannot accurately represent the patchy composition of a horse pasture (Foulk et al., 2011). Step Point (StPt; Evans and Love, 1956) is a point-based method. The Equine Pasture Evaluation Disc (EPED; Foulk et al., 2011) is a new point-based method recently developed to achieve a more representative set of data than LPI.

The objective of this study was to select a method from LPI, StPt, and EPED for use in a subsequent grazing study by analyzing mean species prevalence between methods, repeatability of methods, and agreement between methods; and to determine whether the methods differ in suitability for researcher vs. farmer use.

MATERIALS AND METHODS

Research was conducted on Rutgers University's Best Management Practice Demonstration Horse Farm in New Brunswick, New Jersey over a 4-wk period from August to September 2014. Two 1.6-ha pastures were plowed and re-established by planting with orchardgrass (OG; *Dactylis glomerata* L. 'Potomac'), tall fescue (TF; *Festuca arundinacea* Shreb. 'Jesup MaxQ'), and Kentucky bluegrass (KB; *Poa pratensis* L. 'Camas') in 2012 and ungrazed by horses until August 2014. At the beginning of measurement, pastures had sward heights of 24.5 ± 5.0 and 21.0 ± 4.7 cm. Each of the 4 techniques was performed on each of the 2 pastures on 3 separate dates by the same observer.

Three methods for determining species composition were compared; two variations of the LPI method were performed. Using the LPI method (Herrick et al., 2009a), a 30.5-m tape was laid across the pasture and lifted so a pin could be dropped vertically into the sward at regular intervals. The first living plant to touch the pin was recorded. The pin used was a metal marking flag with a diameter of 2 mm. The 2 variations of this method used were 3 transects per pasture with 50 observations each at 0.6-m intervals (LPI 3–50), and 5 transects per

pasture with 30 observations each at 0.9-m intervals (LPI 5–30), each giving a total of 150 observations per field. Transects were placed by visually dividing the pasture into 3 or 5 sections.

A modified StPt method (Evans and Love, 1956) was used, in which the observer traversed the pasture in approximate transects (one pass of the pasture, 5 to 6 steps down the fence line, and another pass parallel to the first) and stopped every 30 steps to lower a pin down a notch on the rubber toe of the boot. The pin entered the sward at a 30° to 45° angle to the ground and the observer identified the first living plant to touch the pin. This was repeated for a total of 100 observations, resulting in approximately 25 passes of the pasture. In this way, it was similar to performing 25 transects with evenly spaced points based on counting steps.

An EPED (Foulk et al., 2011) was used in a similar manner, being tossed 100 times in a zig-zag pattern across the pasture, starting at one end and ending at the other. The disc has an arrow on the edge, and the living plant directly under the tip of the arrow was identified. All estimates were taken by the same observer.

Desired grass species OG, TF, and KB were recorded separately. A fourth grass, creeping bentgrass (CB; *Agrostis stolonifera* L.), had become established in large sections of one pasture and was also recorded separately. All weeds, plant residue, and bare ground were recorded as Other (O).

All data were analyzed using Statistical Analysis System (SAS; SAS Institute, Cary, NC). Methods are often compared using correlation coefficients. Bland and Altman (1986) argue that this comparison does not satisfactorily measure agreement since it should be expected that measurements of the same variable would correlate. Therefore, this study adapted the methods recommended by Bland and Altman. The proportion of each species was plotted against its standard deviation to create a repeatability graph. Low standard deviations indicate high repeatability. Agreement between pairs of methods was then determined by first calculating the overall bias between each pair of methods for each species (averaged across 3 repetitions and 2 fields). The null hypothesis was that bias (the difference between proportions of species observed with 2 methods) would be zero. A generalized linear-mixed effects model procedure of SAS (GLIMMIX) with a logit link was used to test for differences among each species separately. The model accommodated separate variances for each method and was also used to calculate confidence intervals for estimated prevalence for each method,

indicating limits of agreement. When methods were significantly different ($\alpha = 0.05$), pairwise comparisons were performed using a paired *t*-test.

RESULTS AND DISCUSSION

Prevalence

The mean prevalence of each individual plant species is shown in [Figure 1A–E](#). The prevalence of detecting CB ($P = 0.3334$) and OG ($P = 0.4207$) was not significantly different among methods ([Figure 1A](#) and [B](#), respectively). Both LPI 3–50 ($P = 0.0015$) and LPI 5–30 ($P = 0.0084$) detected KB more frequently than EPED, and LPI 3–50 also detected KB more frequently than the StPt method ($P = 0.0326$; [Figure 1C](#)). The EPED method detected TF more frequently than both LPI 3–50 ($P = 0.0317$) and LPI 5–30 ($P = 0.0068$) methods ([Figure 1D](#)). The LPI 3–50 method detected O less often EPED ($P = 0.0186$) and StPt ($P = 0.0209$; [Figure 1E](#)).

It is possible that both of the LPI methods detected KB more frequently than EPED because KB is a fine, short grass which tends to be covered by the tall, broad grasses that bend under the weight of the disc (e.g., TF, OG, and some grassy weeds). This makes the EPED more likely to select taller grasses in the top layer of the canopy. This method may be better suited to shorter pastures, although similarly, it could underestimate bare ground if leaf blades are bent by the disc. However, [Foult et al. \(2011\)](#) found 20 to 100 tosses of the EPED to be statistically not different from 2 LPI transects in Mid-Atlantic horse pastures of 0.4 ha or less, although pasture height was not specified. The EPED was developed in response to the equine “lawn and rough” grazing pattern, where the 2 areas may have vastly different species composition depending on the forage species’ persistence under grazing ([Odberg and Francis-Smith, 1976](#)). A few randomly placed transects may not accurately represent the plant diversity often seen in horse pastures, and the current study did observe several prevalence differences between EPED and the LPI methods. However, fewer differences were observed between the LPI methods and StPt, which also systematically covered the entire pasture area, suggesting that the differences were due to the disc and not the pattern followed.

The increased likelihood of estimating KB by LPI 3–50 compared with StPt may be due to the difference in angle of pin insertion into the canopy. [Wilson \(1960\)](#) illustrated that a pin inserted at an

angle other than 90° has lower variation in relative frequency than one inserted vertically, suggesting that the 30° to 45° angle used in StPt may yield more consistent results. [Tinney et al. \(1937\)](#) assert that a vertical angle (used in LPI) is more likely to contact tall grasses compared with shorter ones. This finding contradicts our results, which could be due to the fact that our measurements were taken while pastures were tall, and KB did grow to a considerable height in patches. Additionally, [Evans and Love \(1956\)](#) mentioned that StPt is more difficult to use in tall, heavy vegetation.

Overall, StPt and LPI 5–30 estimated species prevalence comparable to every other method. It has been suggested that StPt can be used as an alternative to LPI as long as the observer uses a pin and not just the toe of the boot ([Herrick et al., 2009b](#)). There were no statistical differences between prevalence estimates of the 2 LPI techniques, likewise for EPED and StPt. The most dissimilar prevalence estimates were between EPED and LPI 3–50, which estimated prevalence differently for each of the categories.

Repeatability

All repeatability plots ([Figure 2A–D](#)) displayed lower method repeatability as species prevalence increased, with EPED ([Figure 2A](#)) displaying the strongest trend. This trend is particularly apparent for CB, which was highly prevalent in one field but not the other and creates 2 easily discernable points on the graph for each field. The field with lower prevalence also had much lower standard deviation, regardless of method. [Duniway et al. \(2012\)](#) observed a similar pattern of increased standard deviation with increased species prevalence when comparing among-observer variability in classifying plants on images. Although the present study’s prevalence axis ends at 50%, that of [Duniway et al. \(2012\)](#) continues to 100% and they see a decrease in standard deviation as species prevalence increases past 50%. None of the species in the horse pastures were present at more than 50% prevalence.

The grass species with the highest SD in each plot was CB in the pasture where it was more prevalent. This point ranged from about 6% (LPI 5–30) to about 10% SD (LPI 3–50). This is likely due to the difference in transect numbers; with LPI 3–50’s lower number of transects, it is possible that none of them includes a CB patch. Research has shown that the number of transects used affects the power to detect changes in canopy cover ([Brady et al., 1995](#)),

Figure 1. (A–E) Prevalence of detecting creeping bentgrass (A), orchardgrass (B), Kentucky bluegrass (C), tall fescue (D), and other (E) by each method collected in 2 horse pastures in New Brunswick, New Jersey in August and September 2014. EPED = Equine Pasture Evaluation Disc; LPI 3–50 = Line-Point Intercept 3–50; LPI 5–30 = Line-Point Intercept 5–30; and StPt = Step Point. Lines indicate standard deviation. Bars with no letters in common differ at $\alpha < 0.05$.

and likewise, it may affect the repeatability of the method. The 2 methods that required walking the entire pasture had comparable SD for CB. The next highest SD point in each repeatability plot varied between grasses and had a narrower range, between 5% and 7%. This may reflect the methods' varying abilities to estimate plants that grow in patches (CB) vs. those evenly dispersed throughout the pasture (all others). Previous research has reported that both the LPI and StPt methods are repeatable, with StPt having SD of about 5% in each botanical category with different observers (Evans and Love, 1956; Everson and Clark, 1987; Herrick, 2009b).

Agreement

Table 1 illustrates that 5 of the 30 grass-method pairings exhibited overall bias ($P < 0.05$), meaning that the difference in detecting species prevalence of a grass category between the 2 methods was different from 0. Three of the 5 biased pairings were LPI 3–50 and EPED, suggesting poor agreement. The LPI 3–50 method detected KB more often than EPED ($P = 0.011$) and TF and O less often than EPED ($P \leq 0.017$). This supports the prevalence findings that EPED and LPI 3–50 were the most dissimilar. The other 2 biased pairs consisted

Figure 2. (A–D) Repeatability graphs (standard deviation vs. the mean prevalence) of forage species (CB = creeping bentgrass, KB = Kentucky bluegrass, OG = orchardgrass, TF = tall fescue, and O = other) collected by the Equine Pasture Evaluation Disc (A; EPED), Line-Point Intercept with 5 transects of 30 observations each (B; LPI 5–30), Line-Point Intercept with 3 transects of 50 observations each (C; LPI 3–50), and Step Point (D; StPt) methods in 2 horse pastures in New Brunswick, New Jersey in August and September 2014. Each point represents 3 repetitions of the method. Each symbol represents a different forage species.

of EPED detecting TF more often than LPI 5–30 ($P = 0.033$) and LPI 5–30 detecting TF less often than StPt ($P = 0.040$). No overall bias was found between LPI 5–30 and LPI 3–50, between EPED and StPt, or between LPI 3–50 and StPt for any category. (Table 1).

For all 5 biased pairs, the largest difference in mean species prevalence was 7.2%. Excluding the biased EPED/LPI 3–50 pairs, the 2 remaining biased pairs (EPED/LPI 5–30 and StPt/LPI 5–30) had differences of 5.2% and 3.3%, respectively, which may be more acceptable to a researcher from an interchangeability standpoint. The 95% confidence intervals around the mean biases for the 5 pairs indicate that the limits of agreement were all within 5% of the mean bias (calculated as half the range of values between upper and lower limits) (Table 1).

Notes on Practicality of Each Method

The StPt and EPED methods could be performed with a single person, but the LPI methods benefit from 2 people to stretch the tape taut

when placing it. All methods were easier with an assistant to record observations. The EPED method was found to be inconvenient, because windy days interfered with the observer's ability to toss the disc consistently; even a light gust of wind affected the toss direction and length, usually more so in 1 direction. The LPI methods were tedious and fatiguing due to repeated squatting and kneeling for approximately an hour at a time. This can be an important consideration when performing measurements several times in 1 d. Walker (1970) stressed the importance of avoiding physical stress in observers, as concentration and enthusiasm declined after long sampling periods. Moderate wind also affected the observer's ability to drop the pin vertically into the sward using the LPI methods. Both StPt and EPED have been recommended to farm owners as simple and practical methods to evaluate their own pastures (Burk and Taylor, 2010; Foulk et al., 2011), and the authors would agree. The StPt method was the most user-friendly in terms of ease and physical stress, although care must be taken not to bias foot placement by watching steps.

Table 1. Test of overall bias (indicated by *P*-value), mean bias, and 95% limits of agreement between pairs of pasture species prevalence estimation methods by species, collected in 2 horse pastures in New Brunswick, New Jersey in August and September 2014

Species ¹	Pair of methods ²	<i>P</i> -value	Mean bias	Lower limit of agreement	Upper limit of agreement
CB	EPED–LPI350	0.4187	–1.1667	–4.5708	2.2375
CB	EPED–LPI530	0.3448	–1.9444	–6.7378	2.8490
CB	EPED–StPt	0.1203	2.8333	–1.0604	6.7271
CB	LPI350–StPt	0.2135	4.0000	–3.2166	11.2166
CB	LPI530–StPt	0.1831	4.7778	–3.1736	12.7291
CB	LPI350–LPI530	0.6598	–0.7778	–5.0545	3.4989
KB	EPED–LPI350*	0.0114	–7.1667	–11.8846	–2.4487
KB	EPED–LPI530	0.1234	–5.8333	–13.9343	2.2677
KB	EPED–StPt	0.2014	–3.6546	–10.0431	2.7338
KB	LPI350–StPt	0.0736	3.5120	–0.4871	7.5112
KB	LPI530–StPt	0.2870	2.1787	–2.5229	6.8803
KB	LPI350–LPI530	0.4757	1.3333	–3.1135	5.7802
O	EPED–LPI350*	0.0045	6.2222	2.9581	9.4863
O	EPED–LPI530	0.2168	3.8889	–3.1862	10.9640
O	EPED–StPt	0.5856	1.6271	–5.5547	8.8090
O	LPI350–StPt	0.0636	–4.5951	–9.5686	0.3785
O	LPI530–StPt	0.2078	–2.2617	–6.2822	1.7587
O	LPI350–LPI530	0.2446	–2.3333	–6.8836	2.2169
OG	EPED–LPI350	0.3157	–1.2778	–4.2247	1.6691
OG	EPED–LPI530	0.3814	–1.2778	–4.7011	2.1455
OG	EPED–StPt	0.2918	–2.7182	–8.6503	3.2139
OG	LPI350–StPt	0.5992	–1.4404	–8.0441	5.1632
OG	LPI530–StPt	0.4590	–1.4404	–6.0581	3.1772
OG	LPI350–LPI530	1.0000	0	–3.5398	3.5398
TF	EPED–LPI350*	0.0170	3.3889	0.9112	5.8666
TF	EPED–LPI530*	0.0328	5.1667	0.6285	9.7048
TF	EPED–StPt	0.1239	1.9124	–0.7478	4.5725
TF	LPI350–StPt	0.2447	–1.4765	–4.3565	1.4035
TF	LPI530–StPt*	0.0404	–3.2543	–6.2977	–0.2109
TF	LPI350–LPI530	0.2585	1.7778	–1.8079	5.3634

¹CB = creeping bentgrass; KB = Kentucky bluegrass; OG = orchardgrass; TF = tall fescue; O = other.

²EPED = Equine Pasture Evaluation Disc; LPI 3–50 = Line Point Intercept (3 transects of 50 points); LPI 5–30 = Line-Point Intercept (5 transects of 30 points); StPt = Step Point.

*Significant at the 0.05 probability level.

Without the time-intensive task of harvesting and sorting an entire field, it is impossible to analyze true accuracy of desirable species composition estimation methods. Although LPI is commonly accepted as a pasture standard, it does not represent the entire field, especially when a low number of transects are used. According to prevalence and agreement data, LPI 3–50 and LPI 5–30 may be used interchangeably. The 2 methods that involved walking the entirety of the pasture instead of using transects, EPED and StPt, also showed no differences in prevalence and agreement. The most dissimilar methods were EPED and LPI 3–50. Although there was a bias of 3.3% between StPt and LPI 5–30 in estimating prevalence in 1 grass species, StPt otherwise agreed well with all other methods and appears to be a suitable alternative to the transect methods.

Despite the single bias between the transect methods and StPt, overall, this study concludes that they are comparable in estimating desired grass species composition when sampling cultivated, temperate horse pastures with a mix of short and tall cool-season grasses for research purposes. For farmer use, the authors would recommend either StPt or EPED due to ease of use, more representative sampling, and agreement between the 2 methods. For research investigator use, the authors would recommend either LPI 5–30 due to the larger number of transects or StPt. Because StPt was more representative of the entire pasture area, a less fatiguing method for the observer, and agreed closely with LPI methods, it was the chosen method to estimate grass species composition in a subsequent field

study investigating horse grazing systems over a 2-yr period (Kenny, 2016). Future work based on these findings should examine the effects of grazing horses on pasture botanical composition while comparing management variables such as grazing system, daily proportion of time spent grazing, and time elapsed after grazing in pasture recovery analysis.

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