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<u>Short Communication</u>

Evaluating veld condition index: how many samples is enough?

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Introduction

Ecological surveying underpins evidence-informed approaches to habitat management (Lindenmayer and Likens, 2010; Goodenough and Hart, 2017). Grasslands in southern Africa are often managed to increase productivity and biodiversity (Carbutt et al., 2011) and the Veld Condition Index (VCI) is commonly used to assess condition and inform appropriate management interventions (Tainton et al., 1980; Vorster, 1982; Hurt and Bosch, 1991).

VCI involves identification of grasses, usually at 1 m intervals along a 100 m or 200 m transect (van Oudtshoorn, 2018 and Tainton et al., 1980, respectively) producing either 100 or 200 samples. Each species is assigned to an ecological group based on its ecological status as per published sources (e.g. van Rooyen and Bothma, 2016; van Oudtshoorn, 2018). Each ecological status has an associated multiplier and the overall Ecological Condition Index (ECI) is calculated by summing the number of sampled grasses in each ecological group and then multiplying that total by the corresponding multiplier (van Oudtshoorn, 2018). The total ECI value allows the condition of the sampled veld to be determined using threshold values: poor (<400), moderate (400-599), or good (600+) as per Tainton et al. (1980) and Heard et al. (1986). Condition assessments are used to inform management interventions including rotational burning, mowing, moving animals from over-utilised to under-utilised veld (and vice-versa) or reducing herbivore numbers by translocation or culling (Tainton, 1999; van Rooyen and Bothma, 2016).

The VCI/ECI approach is widely used because it provides a conceptually straightforward method of producing an ecological assessment that can be used to inform management (Ngwenya, 2012). However, the technique is time-consuming and the number of samples that are required to obtain an accurate ECI has not, to date, been assessed. Here, we analyse randomly selected subsamples of 25,200 grass identifications across 36 separate sites to determine the sample sizes required to reach 95% and 99% of the overall ECI value for each site. Our findings suggest that currently recommended VCI sample sizes may be far larger than are actually required.

Methods

This study was carried out in autumn 2019 in Northwest Province, South Africa, on a 4,700 ha site comprising veld and mixed acacia scrub. The site supports ~1,500 individuals from 49 large mammal species including white rhinoceros (*Ceratotherium simum*), blue wildebeest (*Connochaetes taurinus*), zebra (*Equus quagga*) and giraffe (*Giraffa camelopardalis*).

Study sites (n = 36) were selected using systematic random sampling in accordance with Foran et al. (1978) and Trollope et al. (1989) with each being predominately veld of a consistent sward height. At each site, seven parallel 100 m VCI transects were undertaken, each separated by 2 m. A survey cane was used and the single grass species closest to the cane after each 1 m step was identified ("spike-point sampling" (Ngwenya, 2012)). The ecological status and relevant multiplier (Decreaser = 10, Increaser I = 7, Increaser II = 4, Increaser III = 1) of each identified grass species was ascertained using van Oudtshoorn (2018). This gave a grand total of 25,200 grass identifications, 700 at each of the 36 sites.

For each site, the 700 grass identifications were converted to their multiplier value (for example, a Decreaser species would score 10). A site-level ECI value was calculated using all 700 data points based on the percentage occurrence of Decreasers, Increaser I, Increaser II and Increaser III in the full dataset; this is henceforth termed 'overall ECI'. Then, ECI was also calculated using randomly selected subsamples of the full dataset such that subsamples were created that allowed the calculation of ECI based on 699 randomly selected data points, 698 data points, 697 data points and so on, down to a minimum of 10 data points. This gave 690 ECI subsample estimates, as well as the overall ECI, for each of the 36 sites (691 ECI values per site * 36 sites = 24,876 ECI values). For every site, we calculated the percentage difference between each of the 690 ECI estimates created using the randomly selected data points in relation to the overall ECI for that site. This was done using absolute percentage difference (i.e. not accounting for whether the estimate was above or below the overall ECI). The mean of these estimates was then calculated for each sample size (i.e. for 699 samples, 698 samples and so on). Using these means, we identified how many samples were necessary to attain 95% accuracy and 99% accuracy in relation to the overall ECI values.

To compare the ECI estimates made using the full dataset with those made using 100 samples and 200 samples (the sample sizes recommended by van Oudtshoorn (2018) and Tainton et al. (1980), respectively), and those needed for 95% and 99% accuracy, a repeated measures ANOVA was undertaken in SPSS v24.

Results and Discussion

The accuracy of the ECI estimates on the subsamples relative to the overall ECI (calculated on all 700 samples) increased as sample size increased, as might be expected. The gains in accuracy were logarithmic, such that the increase in accuracy with sample size was greatest at low samples sizes and lowest at high sample sizes (Figure 1). A sample of just 43 data points was needed to achieve 95% accuracy relative to the overall ECI but a sample size of 423 data points was needed to reach 99% accuracy. This is an order of magnitude increase in sample size (and effort) to improve accuracy by just four percentage points. If undertaking a VCI based on 100 sample points, as per the recommendation of van Oudtshoorn (2018), mean accuracy was 97.04%; if 200 sample points were used as per Tainton et al. (1980) mean accuracy improved only slightly to 97.87%. Overall, a very modest gain in accuracy (0.83 percentage points) required a doubling of field effort, which could be prohibitive for practical management in time-limited contexts.

There was no statistically significant difference between the site-specific ECI values based on all 700 samples compared to those based on 43 samples (the sample size needed for 95% accuracy), 423 samples (the sample size needed for 99% accuracy), or the two most commonly-used sample sizes of 100 and 200 (Greenhouse-Geisser corrected repeated measures ANOVA: $F = 0.451$, d.f. = 2.597, $P = 0.689$, LSD post-hoc P values ≥ 0.266 in all cases; Figure 2).

In practice, our findings suggest that far fewer samples than are normally recommended can give accurate ECI values, at least in the veld assessed in this study. This translates into large savings in terms of time and effort. Our recommended sample sizes should be interpreted cautiously since veld across southern Africa is diverse (van Oudtshoorn, 2018) and local variation in diversity and heterogeneity will likely influence optimal sample size. We thus recommend that where the VCI/ECI approach is used to assess veld, practitioners determine the minimum sample size necessary required to obtain acceptable levels of accuracy at their sites.

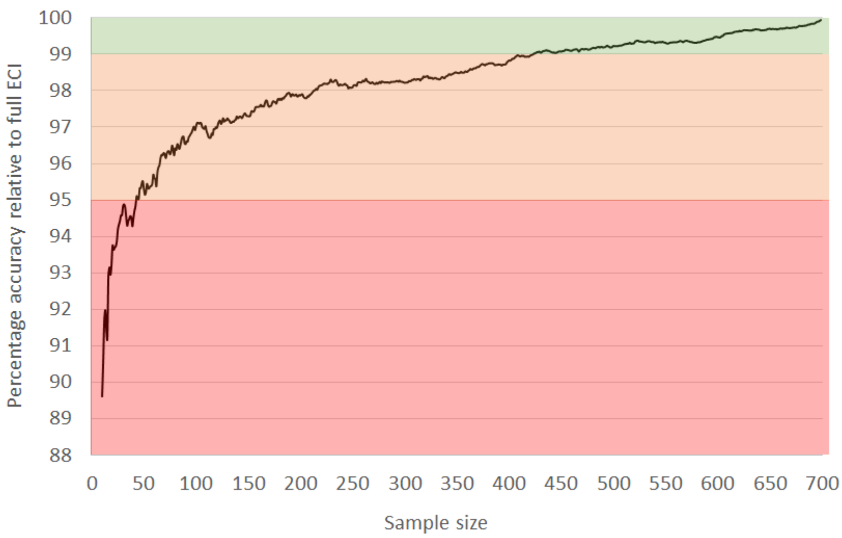

Figure 1: The percentage accuracy of mean ECI values calculated from randomly selected subsamples based on 36 separate sites compared with the overall ECI for each site increased with sample size but reached 95% accuracy (amber zone) with 47 samples. To achieve 99% accuracy (green zone) required 423 samples.

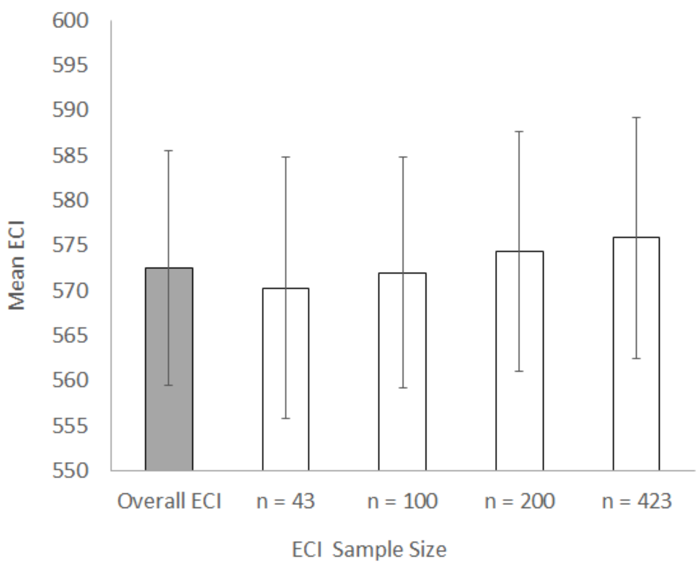

Figure 2: Mean ECI values from 36 sites as calculated using 700 samples (Overall ECI; grey bar), and randomly selected subsamples of sizes based on 95% accuracy (n = 43), 99% accuracy (n = 423), and commonly recommended sample sizes of n = 100 and n = 200. Error bars are standard deviation.

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Conflict of Interest

The authors declare that they have no conflict of interest

Data Availability Statement

Data will be available on publication via eprints.glos.ac.uk as “Hart, A.G. (TBC) Dataset supporting VCI evaluation” (see references).

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