Field Methods for Measuring Plant Species Abundance: A Comparison of Visual Cover Estimates, Presence/ Absence Measurements, and the Point-Intercept Method

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ABSTRACT: Long-term monitoring of plant communities requires non-destructive field methods for measuring species abundances. In the arctic, visual cover estimates, presence/absence measurements, and the point-intercept method are commonly used for this purpose. This research assesses the utility of these methods for long-term monitoring in terms of time efficiency, reproducibility, and accuracy in alpine tundra communities of southern Yukon Territory. In the summer of 2011, plant species abundances at n=12 1 m^2 study plots were repeatedly measured by 2 observers using the point-intercept method, and by 4 observers using visual cover estimates and presence/absence measurements. Time required to complete each measurement was recorded. Plant species abundances at the study plots were accurately measured by harvest of aboveground biomass after non-destructive measurements were complete. Preliminary results indicate that, of these methods, visual cover estimates and presence/absence measurements are the most time efficient, the point-intercept method and presence/absence measurements are the most reproducible between observers, and the point-intercept method and visual cover estimates are the most accurate relative to plant biomass.

BACKGROUND

One important step towards implementing long-term monitoring efforts is the development of effective, non-destructive field methods for the measurement of species abundance. An ideal field method should be

a) Time efficient, due to the logistic difficulties presented by the remote location and short productive period of arctic ecosystems,
b) Reproducible between observers, as studies of broad spatial and temporal scope may require more than one researcher to accomplish, and
c) Accurate, i.e. provide measurements which are correlated with an indicator of the true population value, such as plant biomass.

Below is a brief review of visual cover estimation, the point-intercept method, and presence/absence measurements, three commonly used methods for measuring plant species abundance in the alpine tundra. Each method is briefly discussed in the context of time efficiency, reproducibility, and accuracy.

Visual cover estimation

Visual estimation is a common and time efficient means of measuring cover. Cover is generally measured as the vertical projection of a plant species on the surface of the ground expressed as a percent of the total reference area (Mueller-Dombois & Ellenberg 1974).

Reproducibility of estimates between observers can be quite low. For example, one study in the forest understory of south-central Alaska showed high variability among visual cover estimates performed by six experienced observers. The authors concluded that coarse cover classes (i.e. <20%, 20% to 80%, and >80%) should be used, and that numerous observers should contribute to an average estimate of cover, in order to yield reproducible results (Helm & Mead 2004).

Significant linear correlations between visual cover estimates and aboveground biomass have been observed in several environments. These relationships are typically robust in regions of sparse vegetation, such as arid, temperature limited, or nutrient limited environments; where communities are recovering from disturbance (Rottgermann *et al*. 2000); or in the understory of coniferous forests (Muukkonen *et al.* 2006). However, among communities with a significant vertical structural component the relationship between cover and biomass can be non-linear (Chen *et al.* 2009).

Point-intercept method

The point-intercept method is theoretically more reproducible between observers than visual cover estimates, but requires more time to perform. A set of sample points are established above a plot and the species which occupy the space directly below each point are recorded. This is often accomplished by lowering pins at 100 intersections of a frame positioned above a 1 m^2 sample plot (Mueller-Dombois and Ellenberg, 1974). The total number of pin hits has been shown to be linearly correlated with biomass for both low-growing vegetation (Jonasson 1988) and vegetation with a significant vertical component (Shaver *et al*. 2001). Data describing the reproducibility of point-intercept measurements in the arctic is rare. This method can risk excluding species that are rare or minute, simply due to sampling error (Symstad *et al*. 2008).

Presence/ Absence Measurements

In presence/absence measurements, a set of subplots is established within the area of study, and species found within each subplot are recorded. The proportion of all subplots within which a species is found is then used as a measure of abundance (Mueller-Dombois and Ellenberg 1976). This method is considered very time efficient, and has been shown to have a high degree of reproducibility between observers relative to visual cover estimates (Ringvall 2005). However, the abundance values obtained are sensitive to both the size of the plots and to the specific spatial distribution of plant species (Critchley and Poulton 1998), and would not be expected to be linearly correlated with plant biomass.

RESEARCH OBJECTIVES

The objective of this research is to evaluate the time efficiency, reproducibility, and accuracy of visual cover estimates, presence/absence measurements, and the point-intercept method in low-shrub tundra.

The analysis has three components:

1) Comparing time efficiency between methods and between observers using records of time taken to complete measurements.
2) Evaluating the reproducibility of each method by comparing measurements made by different observers.
3) Comparing accuracy between observers and between methods by assessing the relationship between non-destructive measurements and accurate abundance data obtained by harvest of aboveground biomass.

METHODS

Field data was collected in summer 2011 in alpine tundra of the Wolf Creek watershed roughly 20 km south of Whitehorse, Yukon Territory (N 60.56’ W 135.13’, 1560 m.a.s.l). Four observers of varying experience levels contributed measurements for analysis. One observer had extensive experience using these methods (“experienced observer”), 2 observers had some experience or training in the use of these methods (“moderately experienced observers”), and 1 observer had no experience using these methods (“inexperienced observer”).

At n=12 1 m^2 vegetation quadrats, 2 observers (1 experienced and 1 moderately experienced) measured plant species abundance at the study plots using the point-intercept method. All 4 observers measured plant species abundance using visual cover estimates and presence/absence measurements. Presence/absence was recorded as the sum of species occurrences in 10, 0.1 m^2 subplots within a 1 m^2 quadrat. Following non-destructive measurements, aboveground plant biomass was harvested, sorted by species, dried and weighed.

At an additional n=12 plots, 3 observers (moderately experienced and inexperienced) measured plant species abundance using visual cover estimates and presence/absence measurements. This data is presented here only to assess changes in time efficiency over time for less experienced observers.

RESULTS

Analysis of the data collected in summer 2011 is in progress. Below, I present some of the preliminary trends observed.

Time efficiency

The average time required to complete measurements at a plot varied between methods and observers. The time required for an experienced observer to complete measurements was relatively constant, while the time required for the moderately experienced and inexperienced observers to complete measurements was initially high and generally declined after the first 4-6 plots (Figure 1). For experienced and moderately experienced observers, the average time required to make visual cover estimates and presence/absence measurements was typically less than the time required to make point-intercept measurements (Figure 2). The moderately experienced and inexperienced observers made measurements at 12 additional plots using visual cover estimates and presence/absence measurements after the 12 main plots were complete; for these plots, the average time required was more comparable to the time required for an experienced observer to perform these measurements (Figure 3).

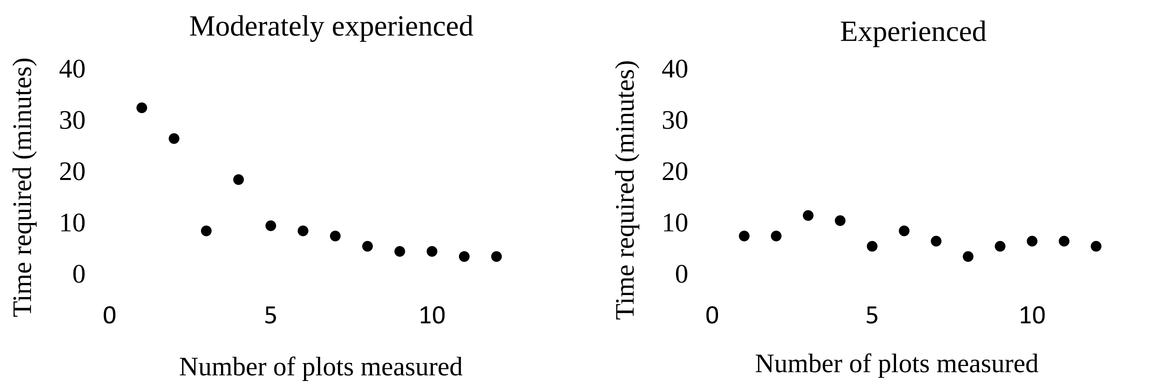
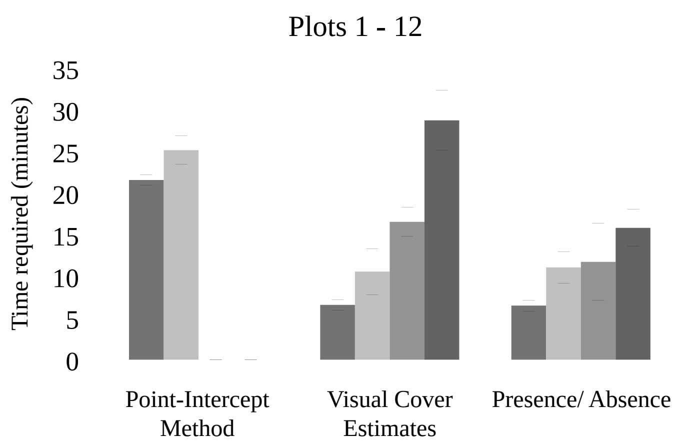


Figure 1: Example data showing change in time required to complete measurements as data collection progressed. Data shown is for a moderately experienced and an experienced observer performing visual cover-estimates.



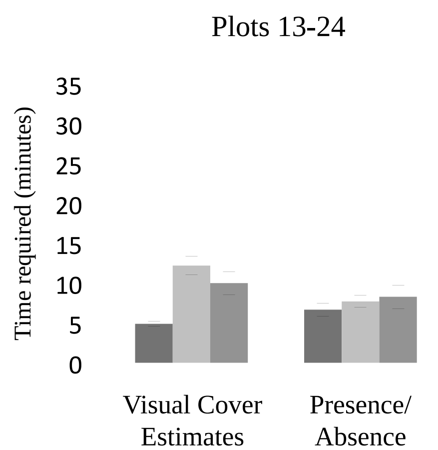


Figure 2: Average time required by different observers to complete measurements using the point-intercept method, visual cover estimates, and presence/absence measurements. Error bars show the standard error of the estimate. Within each method, data is presented with observer experience decreasing from left to right.

Figure 3: Average time required by moderately experienced and inexperienced observers to perform visual cover estimates and presence/ absence measurements during an additional 12 plots. Error bars show the standard error of the estimate. Within each method, data is presented with observer experience decreasing from left to right.

Reproducibility

The average abundance of several widely distributed species as measured by different observers is shown in Figure 4. Abundance values measured using visual cover estimates appear to show high inter-observer variability. In contrast, abundance estimates typically closely overlapped for observers using either point-intercept or presence/ absence sampling. This is consistent with previous studies that have reported that visual cover estimates are often affected by observer bias. The data shows some indication that bias in visual estimates may be directional, with certain observers consistently over- or under- estimating cover relative to other observers. This trend is most evident for measurements of *Salix reticulata*, *Carex rupestris*, and *Pedicularis lanata.*

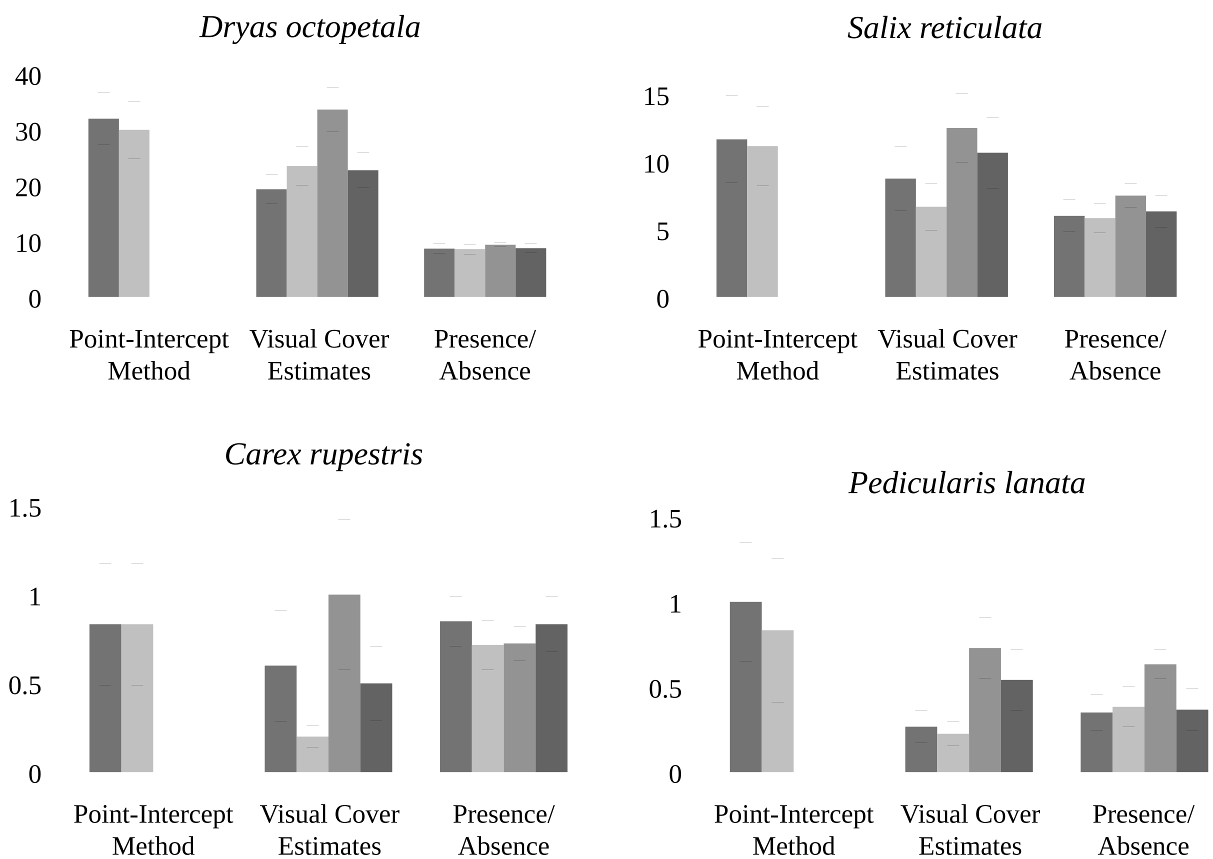


Figure 4. Average abundance values for *Dryas octopetala*, *Salix reticulata*, *Carex rupestris*, and *Pedicularis lanata* as measured by different observers using three different methods. Within each method, data is presented with observer experience decreasing from left to right. Error bars show the standard error of the estimate. Note that differences between methods should not be inferred from these charts as units of measurement differ between methods (point-intercept method is shown as total # of hits/m^2; visual cover estimates as % of total area; presence/absence measurements have been scaled down for comparison and are shown without units).

Accuracy

The accuracy of non-destructive measurements was assessed by comparison to biomass harvesting data (Figure 5). The degree to which non-destructive measurements are correlated with biomass appears to vary between observers, between methods, and between species (Table 1). The measurements made by the point-intercept method and visual cover estimation appear to be more highly correlated with measured biomass than presence/absence measurements. Whether the experience level of the observer has an effect on the degree of correlation is not clear.

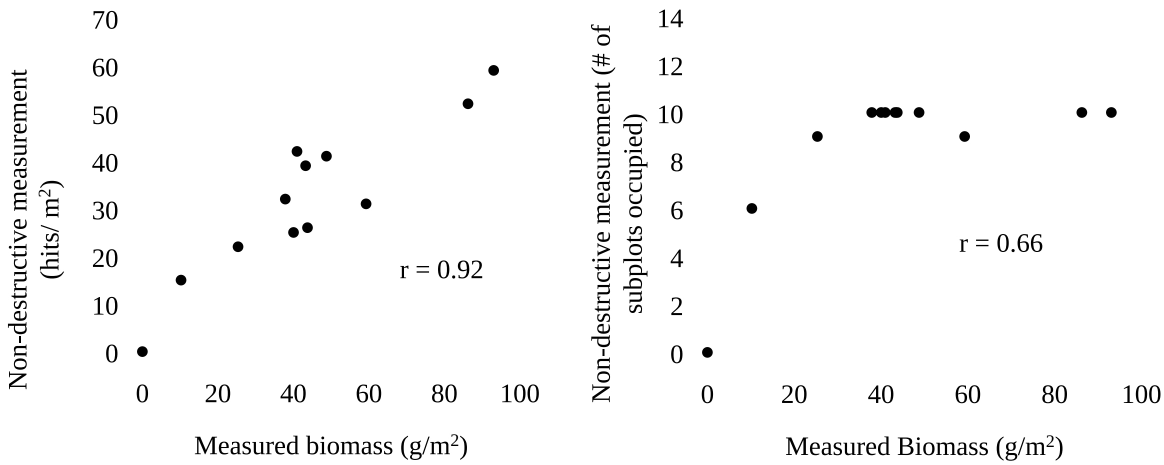


Figure 5: Examples of the relationship between non-destructive measurements of abundance and measured biomass. Data shown is for an experienced observer performing point-intercept (left) and presence/absence (right) measurements of *Dryas octopetala*.

Table 1: r values describing the degree of correlation between non-destructive measurements and measured biomass for *Dryas octopetala* and *Salix arctica*. r values are shown for each combination of non-destructive method and observer. PIM = point-intercept method, VCE = visual cover estimation, P/A = presence/absence. E = experienced observer, M = moderately experienced observer, I = inexperienced observer.

Dryas octopetala

		Observer			
		E	M	M	I
Method	r (PIM)	0.92	0.96	-	-
	r (VCE)	0.91	0.91	0.91	0.85
	r (P/A)	0.66	0.68	0.64	0.64

Salix arctica

		Observer			
		E	M	M	I
Method	r (PIM)	0.98	0.93	-	-
	r (VCE)	0.73	0.97	0.99	0.97
	r (P/A)	0.80	0.77	0.76	0.70

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