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Estimating Aboveground Net Primary Production in Grasslands: A Comparison of Nondestructive Methods

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Abstract

Aboveground net primary production (ANPP) is an important ecosystem property that is affected by environmental variability. ANPP in grasslands is typically measured by clipping peak live plant material. However, this method is time intensive (and therefore expensive), making it difficult to capture spatial and temporal variability. Additionally, it is impractical to use a destructive method to estimate ANPP in long-term, permanent plots. Thus, many double-sampling techniques have been developed to reduce costs and increase sample size. The objective of our study was to assess the accuracy and precision of nondestructive techniques to estimate ANPP as supplements to the traditional method of peak biomass harvest at two grassland sites. We harvested biomass and compared estimates from the same plots to 1) canopy interception using a point frame, 2) green cover estimates derived from a digital camera, and 3) reflectance measurements using a handheld radiometer. We calculated the optimum allocation of sampling effort to direct and indirect methods to minimize sampling cost yet achieve a desired precision. We found that the point frame technique explained the highest proportion of the variability in biomass at both sites ($R^2 = 0.91, 0.90$). However, our cost-optimization analysis revealed that the radiometer technique, although less accurate ($R^2 = 0.38, 0.51$), could achieve a desired precision for lower labor costs than the point frame. The radiometer and point frame methods will be a useful tool for grassland ecologists and rangeland managers who desire fast, nondestructive estimates of ANPP.

Resumen

La producción primaria neta PPN es una propiedad importante en el ecosistema que es afectada por la variabilidad medioambiental. La PPN en pastizales se mide normalmente por medio de cortes de la parte viva de la planta. Sin embargo, este método consume mucho tiempo (y es caro) haciendo difícil estimar la variabilidad espacial y temporal. Además, es impráctico usar métodos destructivos para estimar la PPN en el largo plazo en parcelas permanentes. Por esto, técnicas de doble muestreo se han desarrollado para reducir el costo y aumentar el tamaño de muestra. El objetivo de nuestro estudio fue evaluar la eficacia y eficiencia de técnicas no destructivas para estimar la PPN como complementos del método tradicional de cosecha de la biomasa en dos tipos de pastizales. Se cosecho la biomasa y se comparo las estimaciones de las mismas parcelas para 1) intercepción del dosel con el método del punto, 2) estimación de la cubierta verde derivada de una cámara digital, y 3) medidas de reflejo usando un radiómetro manual. Calculamos la ubicación óptima de esfuerzo de muestreo por métodos directos e indirectos para reducir el costo de muestreo y lograr la precisión deseada. Encontramos que la técnica del punto explico la mayor proporción de la variabilidad de biomasa en ambos sitios ($R^2 = 0.91, 0.90$). Sin embargo, el análisis optimización-costo revelo que la técnica del radiómetro aunque menos precisa ($R^2 = 0.38, 0.51$) podría lograr la precisión deseada con menor costo que el punto. Los métodos del radiómetro y el punto serán herramientas útiles para ecólogos y manejadores de pastizales que requieren de estimaciones de PPN rápidas y no destructivas.

Key Words: cost optimization, double sampling, handheld radiometer, mixed grass prairie, point frame, shortgrass steppe

INTRODUCTION

Aboveground net primary production (ANPP) is an important attribute of ecosystems, and quantifying ANPP is a frequent goal of basic and applied ecology (Sala and Austin 2000). Estimates of ANPP are necessary to understand the global carbon balance and trophic interactions. McNaughton et al. (1989) proposed that net primary production can be used as

an integrative ecosystem variable because it both reflects and influences other trophic levels. From an applied perspective, estimates of ANPP are used to determine forage availability and stocking rates for livestock and managed wildlife populations in rangelands, as well as wood yield in forests.

ANPP is the amount of aboveground plant biomass or carbon accumulated over a specific time period. Singh et al. (1975) reviewed different methods of harvesting standing biomass to estimate ANPP. The simplest and most common technique in grasslands is to clip green and current year dead material of grasses and forbs and current year green production (excluding woody tissue) for dwarf shrubs at peak biomass. This method has been shown to produce estimates with low uncertainty (Lauenroth et al. 2006) and

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