Forest Ecology and Management 432 (2019) 409–414

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Maximizing the monitoring of diversity for management activities: Additive partitioning of plant species diversity across a frequently burned ecosystem

Jane E. Dell[a,*], Scott M. Pokswinski[b], Lora A. Richards[a], J. Kevin Hiers[b], Brett Williams[c], Joseph J. O'Brien[d], E. Louise Loudermilk[d], Andrew T. Hudak[e], Lee A. Dyer[a]

[a] University of Nevada, Reno, Ecology, Evolution, and Conservation Biology, 1664 N. Virginia St./MS 0314, Reno, NV 89557, USA
[b] Tall Timbers Research Station, Wildland Fire Science Program, 13093 Henry Beadel Dr, Tallahassee, FL 32312, USA
[c] Air Force Wildland Fire Center, Eglin AFB, 107 Highway 85 N., Niceville, FL 32578, USA
[d] Center for Forest Disturbance Science, Southern Research Station, US Forest Service, 320 Green St., Athens, GA 30602, USA
[e] Forestry Sciences Laboratory, Rocky Mountain Research Station, US Forest Service, 1221 S. Main St., Moscow, ID 83843, USA

ARTICLE INFO

Keywords:
Species turnover
Beta diversity
Pairwise distance
Variance partitioning
Longleaf pine

ABSTRACT

Monitoring understory plant diversity is important, allowing managers to track current diversity status and trends both spatially and temporally at a landscape-scale. Improving precision in quantifying patterns in understory plant diversity improves efficiency in monitoring design and more accurate measures of success of management intervention over time. Patterns of species diversity are dependent upon the scale in which they are examined – an increase in small-scale diversity across a gradient can convert to a decrease in large-scale diversity across that same gradient. Using two extensive datasets including both mined historical data and supplemental experimental data, we performed an additive partitioning of plant diversity to elucidate the hierarchical spatial patterns of understory plant species richness, and independent measures of alpha and beta diversity in the species-rich longleaf pine ecosystem at Eglin Air Force Base in northwestern FL, USA. This analysis allowed us to identify the spatial scale that most effectively captures plant diversity to inform monitoring efforts by using measures of species turnover, specifically beta diversity. We found that while species richness and alpha diversity increased with spatial scale, beta diversity began to reach an asymptote at smaller (1 m^2) scales. Furthermore, we found the sampling effort at this 1 m^2 scale required as few as 60 plots to effectively estimate plant diversity within management blocks. While our results are attributable to Eglin AFB specifically, these scaling analyses can help to streamline monitoring efforts in other ecosystems that seek to elucidate the individual contributions of diversity components.

1. Introduction

Enumerating and monitoring biodiversity is a critical activity for land managers, allowing for the assessment of management activities and evaluating effects of disturbance on biotic communities (Lindenmayer and Likens, 2010, Legg and Nagy, 2006). Effective monitoring helps to elucidate spatio temporal variation in plant diversity patterns and informs strategies to maintain diversity. Successful monitoring programs are targeted, objective driven, and test *a priori* hypotheses which allow for adaptive management strategies (Nichols and Williams, 2006; Yoccoz et al., 2001). Furthermore, an effective monitoring program measures success with quantifiable objectives (Lindenmayer and Likens, 2010).

Long-term biodiversity sampling schemes often represent a legacy, having been established in the past for many reasons that may no longer be currently relevant, but still represent a valuable resource for interpreting trends in species abundance, impacts of management interventions, and impacts of invasive species colonization (Enquist and Enquist, 2011). Monitoring efforts require costly data collection (Caughlan and Oakley, 2001). Recent literature suggests that despite considerable investment of resources and effort to optimize sampling, the wide range of sampling techniques employed in studies of diversity can negatively effect the accuracy of landscape or regional scale inferences (Eigenbrod et al., 2010). As a result, generalization from targeted monitoring efforts are limited to the local scale at which data are collected (i.e. management unit, Lindenmayer and Likens, 2010). However, efficiency can be gained through the identification of the appropriate spatial scale to monitor biodiversity (Yoccoz et al., 2001).

* Corresponding author.
E-mail address: jane.dell@nevada.unr.edu (J.E. Dell).

https://doi.org/10.1016/j.foreco.2018.09.022
Received 9 July 2018; Received in revised form 9 September 2018; Accepted 13 September 2018
0378-1127/ © 2018 Elsevier B.V. All rights reserved.

One of the most general patterns in nature is the species-area relationship (Lomolino, 2000, MacArthur and Wilson, 1967). As greater spatial areas are sampled, species richness accumulates as a wider range of environmental conditions and associated species are encountered (Sandel, 2015). While this pattern may be repeatable across systems it does not always provide an accurate measure for those interested in managing biodiversity. For instance, richness alone does not provide information regarding community composition at varying spatial scales nor allow for monitoring how community dynamics change in response to management activities. More nuanced studies on the scale-dependence and distribution of species diversity (richness, evenness, and abundance) have contributed significantly to understanding patterns of biodiversity and community structure (Condit et al., 2002; Crawley and Harral, 2001). If patterns detected at larger scales are the result of complex processes occurring at smaller scales, then it is necessary to examine how patterns at variable scales relate to one another (Tello et al., 2015; Levin, 1992).

Whittaker (1972, 1960) partitioned diversity, defining alpha (α) diversity as the local diversity within a single sampling unit, beta (β) diversity as the variation in species composition and abundance (turnover) between sampling units in a geographic area, and gamma (γ) diversity as a measure of regional diversity. Building upon these definitions, Lande (1996) demonstrated analytically that γ-diversity could be partitioned into additive components with total diversity as the sum of average α-diversity and β-diversity ($\gamma = \alpha + \beta$). Therefore, the relative contributions of α-diversity and β-diversity to γ-diversity can be calculated and used to describe changes in diversity across spatial scales (Tello et al., 2015; Tuomisto, 2010; Gering et al., 2003).

Under this framework, an informative metric of diversity for managers interested in the effect of management intervention on plant communities is species turnover or beta diversity. β-diversity reflects the variation of species assemblages in response to management actions, thereby providing greater insight into drivers of community composition across spatial, temporal, or environmental gradients. β-diversity is a key concept for understanding the functioning of ecosystems, patterns in community assembly, and informing ecosystem management (Barwell et al., 2015; Chao et al., 2012; Jost, 2007; Legendre et al., 2005). For example, reduction in β-diversity represents a homogenization in community composition which may reduce ecosystem function by affecting productivity, resilience to disturbance, and vulnerability to biological invasion (Balata et al., 2007). The utility of β-diversity as a measure that can be compared between sites with differing levels of α-diversity requires that the two components be independent (Jost, 2007). In doing so, partitioning diversity into spatially explicit components identifies the most important scale for targeting management efforts. For instance, identifying the spatial scale at which β-diversity is maximized provides a more accurate estimate of biodiversity, allowing monitoring programs to implement a standardized plot size for sampling biodiversity.

Our goal was to examine the impact of sampling area on plant diversity estimates and investigate the influence of sampling intensity to help guide efforts to effectively capture and monitor biodiversity in longleaf pine (*Pinus palustris* Mill.) stands. Longleaf pine ecosystems are ideal for management related studies of plant species diversity as they are characterized by high levels of floristic diversity at fine scales, including numerous rare and endemic species that are maintained in managed landscapes through the use of prescribed fire (Palmquist et al., 2015; Walker, 1993; Hardin and White, 1989; Walker and Peet, 1984). We estimated diversity components in plot areas sampled hierarchically in space (i.e., area), which act as a surrogate for inventorying larger and larger plots, to test hypotheses about optimal scales and metrics for measuring biodiversity in longleaf pine systems. We proposed that spatial scale would have differential impact on alpha and beta diversity components due to spatial aggregation of understory plant species. Specifically, we were interested in finding the spatial scale where β-diversity was maximized over the fixed extent of Eglin Air Force Base (AFB; Sandel, 2015); i.e., – what is the best sampling scale to assess management effects on biodiversity?

2. Methods

2.1. Study site

All data were collected at Eglin AFB located in the Gulf Coastal Plain of the Florida panhandle, USA. Eglin AFB is over 180,000 ha in size, includes over 3500 ha of the estimated 5100 ha of old-growth longleaf pine remaining in the region, and is actively managed by frequent prescribed fire (Mitchell et al., 2009, Hiers et al., 2007; Varner et al., 2005; Varner and Kush, 2004). The climate is typified by hot, humid summers with frequent thunderstorms and lightning strikes, mild winters (Provencher et al., 2001), mean annual temperature of 18.6 °C, and 169.2 cm of annual precipitation during the period of data collection (Vose et al., 2014). The area has relatively little topography (0–100 m ASL) and is dominated by well-drained Lakeland series soils (Overing and Watts, 1989). Past land uses at Eglin included timber extraction and naval stor however the deep, coarse-textured entisols precluded extensive tilling or agricultural land use (B. Williams, personal communication).

Xeric sandhills and mesic flatwoods are the dominant vegetative communities found at Eglin AFB. Longleaf pine is a foundation species and is typically monodominant in the overstory with a relatively open canopy throughout the site. Sandhill ground cover vegetation contains many plant species and is dominated by several grasses, such as wiregrass (*Aristida stricta* Michx.), little bluestem (*Schizachyrium scoparium* Michx.), broomsedge (*Andropogon virginicus* L.), as well as dwarf huckleberry (*Gaylussacia dumosa* (J. Kenn) Torr. and A. Gray), evergreen blueberry (*Vaccinium darrowii* Camp), and saw palmetto (*Serenoa repens*). Ground cover vegetation in flatwood communities are dominated grasses such as wiregrass, toothache grass (*Ctenium aromaticum* Walter) and shrubs such as dwarf live oak (*Quercus minima* (Sarg.) Small), saw palmetto, and gallberry (*Ilex glabra* (L.) A. Gray).

2.2. Data collection

To quantify the patterns of diversity found in understory plant communities of longleaf pine ecosystems, we collected species area data and supplemented it with Eglin AFB vegetation monitoring data. Datasets included species richness and abundance measures from hierarchically nested plots (> 1–$78\ m^2$), and 201 monitoring plots representing over a decade of sampling at hierarchical scales (1–$100\ m^2$; Hiers et al., 2007). Data were collected by Eglin AFB natural resource technicians, and professional botanists. Due to differences in data collection and study design as described below, datasets were analyzed separately. Additionally, fire history records were available for the majority of plots extending over the entire sampling time period.

2.3. Datasets

2.3.1. Eglin AFB vegetation monitoring dataset

The Eglin AFB Natural Resources Branch monitoring program began collecting fuel and vegetation data for 201, one-hectare plots randomly located across the base in 2001. Plots were stratified within sandhill, flatwood, and plantation plant communities managed as reference stands or for restoration, or as plantations. All plots in the program were sampled one year following management activities (fire, herbicide treatments, and timber harvest) to determine the effects on plant communities. With the regular application of fire occurring every 15–24 months, plots were revisited and resampled on 2–5 occasions between the years 2001–2012. Each plot visit included the measurement of understory species richness in four, 10-m x10-m subplots nested within each monitoring plot based on the North Carolina Vegetation Survey dimensions (Peet et al., 1998). Within each subplot

Download English Version:

https://daneshyari.com/en/article/11028358

Download Persian Version:

https://daneshyari.com/article/11028358

Daneshyari.com