



Retained vegetation density of streamside management zones and stringers in southern intensively managed pine forests



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ABSTRACT

In the southern U.S. (hereafter, South), institutional forest owners engaged in forest certification programs often retain unharvested or less-intensively harvested vegetation when clearcut harvesting intensively managed pine (*Pinus* spp.) forests (IMPFs). As a result, IMPF landscapes consist of regenerating forests and associated retained streamside management zones (SMZs), stringers (buffer strips along ephemeral streams), and other forest types and structural classes. Although studies in the South have documented plant and animal communities associated with SMZs, there is a lack of information about stringers. To improve understanding of the potential for stringers to contribute to biodiversity-related management objectives, we characterized stem density and vegetation cover in SMZs and stringers associated with 60 IMPF management units (MUs) in the South Central Plains ecoregion of Arkansas and Louisiana, USA. Snag and log density, midstory pine density, understory deciduous cover, and ground cover were not statistically different in stringers and SMZs; however, overstory (pine and deciduous) and midstory (deciduous) tree density was significantly lower in stringers than in SMZs, and understory pine density was significantly greater in stringers.

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1. Introduction

Global demand for wood products has led to intensified forest management practices in some regions of the world, including the southern U.S. (hereafter, South; Demarais et al., 2017). There, IMPF increased from 7280 km² to 129,000 km² during 1950–2000, and is expected to supply 50% of the softwood removals from all forests in the South (Fox et al., 2007; Smith et al., 2009). Because IMPFs are extensive in area and actively managed, they have significant potential to contribute to biodiversity maintenance and enhancement (Miller et al., 2009; Demarais et al., 2017). Forest landowners engaged in forest certification programs are encouraged to consider conservation goals in their management plans (Miller et al., 2009; Forest Stewardship Council US, 2010;

American Forest Foundation, 2015; Sustainable Forestry Initiative, 2015).

Retention of structural features (e.g., snags and living green trees) is a common strategy to enhance stand-level structural diversity (Franklin et al., 1997; Gustafsson et al., 2012) after forest harvest. Green trees can be retained within harvest units as scattered individual stems, aggregated groups of stems, or as larger patches. In the South, IMPFs are commonly harvested using clearcutting with green trees retained in SMZs and other aggregated areas. As a result, IMPF management units² ('MUs') in the early-establishment phase are dominated by three cover types: (1) RCC, (2) SMZs buffering perennial or intermittent streams, and (3) stringers,³ vegetated buffers retained along ephemeral drains. A

Abbreviations: BMP, best management practices; IMPF, intensively managed pine (*Pinus* spp.) forest; MU, management unit; RCC, regenerating clear cut; SCP, South Central Plains; SMZ, streamside management zone.

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² We defined management units (MUs) as contiguous areas containing one or more intensively managed pine forest ('IMPF') stands that are uniform in age, that were harvested and reestablished as a unified cohort, plus any associated areas of green tree retention (e.g., streamside management zones or stringers).

³ Stringers are vegetated buffer zones located around ephemeral drains and gullies. Watercourses associated with stringers usually feed into larger waterways, which are themselves often protected by SMZs. State best management practices guidelines in the southern US generally address stringers separately from SMZs.

recent study in the SCP ecoregion found that 1,188 commercial MUs averaged 43.5 ha, with mean land cover of 80.5% RCC, 14.0% SMZ, and 3.3% stringer (M.C. Parrish et al., Mississippi State Univ., 2017, unpublished results). By aggregating structural features along riparian corridors in SMZs and stringers, managers are able to provide stream buffering and water quality protection services (Lindenmayer and Franklin, 2002; Seconges et al., 2013), reduce interference with regeneration and subsequent stand treatments, and provide ecosystem services, including: (a) refugia and biological legacies for species associated with mature forests; (b) structural complexity that potentially benefits recolonizing organisms; and (c) enhanced landscape connectivity (Franklin et al., 1997; Lindenmayer and Franklin, 2002; Aubry et al., 2009).

Early-successional forest, which is an important component of IMPF MUs in the pre-canopy closure stage, is an ephemeral resource that is declining in the eastern U.S. (Wilson and Watts, 2000; Trani et al., 2001; King and Schlossberg, 2014). However, retained structural elements, such as SMZs and stringers, also can play a role in conservation of biodiversity on actively managed landscapes by enhancing structural heterogeneity (Poulsen, 2002; Culbert et al., 2013). Most studies assessing biodiversity-SMZ relationships in IMPFs have examined associations with buffer width rather than vertical-axis vegetation structural characteristics (Rudolph and Dickson, 1990; Thurmond et al., 1995; Kilgo et al., 1998; Constantine et al., 2004; Lee et al., 2004; Miller et al., 2004; Perry et al., 2011). Dickson (1989), working in eastern Texas, USA IMPFs, noted positive associations between SMZ vegetation structural complexity and width (i.e., narrow SMZs had pronounced understory layers with minimal canopy or shade, while wider SMZs had open understories and shady, closed canopies), and reported greater small mammal captures in narrow SMZs and larger numbers of reptiles, amphibians, and tree squirrels in wider SMZs. In North Carolina, USA, agricultural SMZ structural diversity positively affected bird community diversity (Smith et al., 2008).

Stringers are commonly retained in many IMPF MUs in the South. A regional-scale study in the SCP found stringers were retained on 69% of MUs (M.C. Parrish et al., Mississippi State Univ., 2017, unpublished results). In many cases, stringers are connected to SMZs and thereby can provide an extension of mature forest cover and habitat for mature forest-associated species into adjacent RCCs. Although we were unable to locate studies addressing biodiversity relationships with stringers in IMPFs, studies in other forest types in the South suggest that some biodiversity responses to stringers may be similar to those in SMZs. In southeastern Kentucky, USA, stringers around ephemeral streams in harvested deciduous forests maintained larger salamander populations than non-buffered ephemeral streams (Maigret et al., 2014). However, the degree of structural similarity between stringers and SMZs has hitherto remained unclear. Thus, our objective was to characterize and compare the patch-scale stem density, understory deciduous (shrub) cover, and ground cover of the two dominant green tree retention cover types occurring on IMPF MUs (i.e., SMZs and stringers) in the South. Of particular interest was the degree of similarity of stem density between stringers and SMZs, as we hypothesized that stringers provide benefits to MU structural diversity that are complementary to those provided by SMZs (Radabaugh et al., 2004).

2. Material and methods

2.1. Study area

The South Central Plains ecoregion (Fig. 1) extends south from central Arkansas and southeastern Oklahoma into northwestern

Louisiana and eastern Texas (Omernik, 1987; US Environmental Protection Agency, 2011). Historically, the SCP was dominated by longleaf (*P. palustris* Mill.) pine forests and savannas in the south and mixed shortleaf pine (*P. echinata* Mill.)-hardwood forest in the north (Little, 1979; Wilkin et al., 2011); the region represents the western edge of the southern pine belt and modern land cover still consists of around 67% woodlands and less than 20% cropland, with extensive area in commercial IMPF (Daigle et al., 2006; Griffith et al., 2007; Wilkin et al., 2011). Winters are mild and summers are hot, particularly in southern parts of the SCP, with mean low and high temperatures of 1 °C and 34 °C, respectively (Griffith et al., 2007). Annual mean precipitation ranges from 105 cm to 170 cm across the ecoregion (Wilkin et al., 2011). Perennial streams are abundant and mostly of low to moderate gradient (Wilkin et al., 2011), and many smaller streams experience limited or no flow during hot summer months (Woods et al., 2004).

Locally-intensive pine silvicultural activity in the South Central Plains (SCP) ecoregion of Arkansas and Louisiana suggests it as an ideal area for studying green tree retention in IMPF. In 2012, 85.0 Mha (39.4%) of the South was in timberland, 16.1 Mha of which was planted loblolly-shortleaf pine (*Pinus taeda* L.⁴ - *P. echinata* Mill.) or longleaf-slash pine (*P. palustris* Mill. - *P. elliotii* Engelm.) (Oswalt et al., 2014). Regional timber production typically occurs on planted timberland that is intensively managed using techniques such as chemical and/or mechanical site preparation, fertilization, and thinning (Jones et al., 2009a; Demarais et al., 2017). In Arkansas and Louisiana, managers typically retain SMZs adjacent to intermittent streams, perennial streams, ponds, and lakes as recommended by state BMP guidelines (Louisiana Department of Agriculture and Forestry, 1999; Arkansas Forestry Commission, 2002).

2.2. Site selection

We selected 60 IMPF MUs in the SCP ecoregion of Arkansas and Louisiana from an initial set of 1,188 MUs⁵ in the SCP established in 2008 or 2009 that would be 3 years post-establishment when sampled during 1 June to 13 July 2011 ($n = 35$) or during 7 May to 19 June 2012 ($n = 25$). Land cover on each of the 1,188 MUs was previously classified as part of a related study, using recent, high-resolution aerial imagery, and a dataset containing class-level spatial metrics was derived for each MU landscape using FRAGSTATS⁶ software (M.C. Parrish et al., Mississippi State University, 2017, unpublished results). From that dataset, we extracted the following spatial metrics relating to our 60 study sites for use in characterizing the dimensions and contributions to stand composition made by SMZs and stringers: (1) total area in land cover class (CA), (2) class percentage of MU landscape (CPL), (3) patch density per 100 ha (CPD), (4) class mean patch area within MU (CMPA), and (5) mean radius of gyration (CMGYR; a measure of linear extent of patch). Criteria for sampling consideration were: (1) MU contained both SMZ and stringer cover (as determined by aerial photo interpretation); (2) MU ranked in the central 80% of the range of MU area (M.C. Parrish et al., Mississippi State University, 2017, unpublished results); and (3) MU was within 60 km of one of 6 logistical hubs located across the SCP (Fig. 1). We ranked the remaining sites by percent green tree retention and stratified them into six equally-sized groups, from which we randomly selected sample sites. We established two 30-m-radius plots, 200 m or more apart, in both SMZ

⁴ Tree taxonomic nomenclature follows Little (1979).

⁵ MUs were managed by Forest Capital Partners, LLC; Plum Creek Timber Company, Inc.; Potlatch Corporation; Resource Management Service, LLC, and Weyerhaeuser Timber Companies.

⁶ FRAGSTATS 4.1 software was used to derive spatial metrics; equations may be found in the program documentation (McGarigal et al., 2012).

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