Forest Ecology and Management 391 (2017) 127–134

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Nocturnal insect availability in bottomland hardwood forests managed for wildlife in the Mississippi Alluvial Valley

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ARTICLE INFO

Article history:
Received 8 November 2016
Accepted 5 February 2017
Available online 23 February 2017

Keywords:
Bats
Bottomland hardwood forest
Desired forest conditions
Insect availability
Mississippi Alluvial Valley
Wildlife forestry

ABSTRACT

Silviculture used to alter forest structure and thereby enhance wildlife habitat has been advocated for bottomland hardwood forest management on public conservation lands in the Mississippi Alluvial Valley. Although some songbirds respond positively to these management actions to attain desired forest conditions for wildlife, the response of other species, is largely unknown. Nocturnal insects are a primary prey base for bats, thereby influencing trophic interactions within hardwood forests. To better understand how silviculture influences insect availability for bats, we conducted vegetation surveys and sampled insect biomass within silviculturally treated bottomland hardwood forest stands. We used passive blacklight traps to capture nocturnal flying insects in 64 treated and 64 untreated reference stands, located on 15 public conservation areas in Arkansas, Louisiana, and Mississippi. Dead wood and silvicultural treatments were positively associated with greater biomass of macro-Lepidoptera, macro-Coleoptera, and all insect taxa combined. Biomass of micro-Lepidoptera was negatively associated with silvicultural treatment but comprised only a small proportion of total biomass. Understanding the response of nocturnal insects to wildlife-forestry silviculture provides insight for prescribed silvicultural management affecting bat species.

1. Introduction

Insects are important in maintaining the health and diversity of forest ecosystems (Andrewartha and Birch, 1984) through pollination and defoliation (Janzen, 1987), as well as influencing nutrient cycling processes (Gorham et al., 2002). Although many studies have focused on silvicultural practices to reduce the impact of insect pests (Berryman, 1986), less attention has been given to understanding how management actions affect abundance and species composition of forest insect communities (Burford et al., 1999; Ober and Hayes, 2008).

Insect abundance is affected by vegetative characteristics such as structural complexity (Gorham et al., 2002), species richness (Haddad et al., 2001), and composition (Schowalter, 1986). Greater densities of woody and herbaceous vegetation generally support greater abundance of insects (Gorham et al., 2002). However, specific insect taxa differ in their response to silvicultural methods and intensities used to promote woody and herbaceous growth (Intachat et al., 1997; Summerville et al., 2004). For example, Burford et al. (1999) found that in Kentucky, abundance of moth families (e.g., Yponomeutidae, Limacodidae, Pyralidae, Geometridae, Notodontidae, and Arctiidae) differed among forest stand age classes. Similarly, Summerville and Crist (2003) found that although there was no difference in moth species richness or abundance between managed and wilderness stands in southern Ohio, the community composition was influenced by management of the surrounding landscape.

Insects provide a major source of food for many wildlife species (Gorham et al., 2002), including bats (Jones and Rydell, 2003). Insectivorous bats, particularly lactating females, are capable of consuming up to 73% of their body weight in insects per night (Kuntz et al., 1995). Although the availability of insect prey for bats is often unknown (Dodd et al., 2012a), the diet of bats includes moths, beetles, and flies (Clare et al., 2009; Hamilton and Barclay, 1998). However, the insect taxa that are consumed vary with bat species morphology, sympatric species and habitat conditions (Dodd et al., 2012a; Fenton, 1990; Freeman, 1981; Menzel et al., 2002).

Silvicultural practices, such as selective harvest, directly impact bat populations within forest stands by changing foraging habitats and roosting sites (Menzel et al., 2002, 2005). Silvicultural treatments prescribed to enhance wildlife habitat by modifying forest

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http://dx.doi.org/10.1016/j.foreco.2017.02.009
0378-1127/Published by Elsevier B.V.

structure (e.g., wildlife-forestry; Twedt, 2012), have been advocated for management of bottomland hardwood forests on public conservation lands within the Mississippi Alluvial Valley (Twedt and Somershoe, 2010; Wilson et al., 2007a). Structural components such as canopy closure, basal area, and tree species richness can be managed through prescribed silviculture. Silvicultural treatments undertaken to enhance wildlife habitat are beneficial to songbirds (Twedt and Somershoe, 2010; Twedt and Wilson, 2007). Loeb and O'Keefe (2006) found early successional habitats and canopy gaps were used by bats for commuting and foraging, but the effect of wildlife forestry treatments on nocturnal insects and bats in the Mississippi Alluvial Valley has not been investigated. Continued application of wildlife silviculture in this region behooves wildlife managers to assess its effect on multiple species. To that end, we compared insect biomass in several orders between forest stands that had been subjected to silvicultural treatments and paired untreated reference stands. In addition, we examined the influence of various forest structural and environmental variables on insect biomass to identify those factors that were important for determining insect abundance in these stands.

2. Methods

2.1. Study location

We surveyed 128 bottomland hardwood forest stands (64 treated and 64 reference) within the Mississippi Alluvial Valley on 15 public conservation lands managed by state wildlife agencies (Wildlife Management Areas, WMA) or the U.S. Fish and Wildlife Service (National Wildlife Refuges, NWR) during April to August 2013, and May to August 2014. Surveyed WMA and NWR (hereafter referred to as "locations") were in Arkansas (Cache River NWR, Dagmar WMA, White River NWR), Louisiana (Bayou Cocodrie NWR, Big Lake WMA, Boeuf WMA, Dewey Wills WMA, Red River WMA, Russell Sage WMA, Three Rivers WMA, Tensas River NWR), and Mississippi (Morgan Brake NWR, O'Keefe WMA, Panther Swamp NWR, Yazoo NWR; Fig. 1).

We surveyed locations sequentially starting from the southernmost to the northernmost location to account for seasonal change within temperate deciduous forests that may influence our focal taxa (Hayes, 1997). Surveyed stands (i.e., finite forest areas subjected to a common silvicultural prescription: often referred to as "management units" or "compartments") were mature bottomland hardwood forests. At each study location (WMA or NWR), managers identified stands that were silviculturally treated to enhance wildlife habitat within the past 12 years. We restricted selection of treated stands to $\leq$12 years post-treatment because the predominant effects of silvicultural treatments on birds diminished after circa 12 years (Twedt and Somershoe, 2010; Twedt and Wilson, 2007).

Silvicultural treatments, including group selection, small patch clearcuts, and individual tree selection (Meadows and Stanturf, 1997), were prescribed based on stand conditions and management objectives. Treatments were applied individually or in combination within a single treated stand. Regional application of silvicultural treatments varied among locations and year of application (Twedt and Wilson, 2016). Mean area of treated stands was 168 ± 151 ha (n = 64) with each treated stand encompassing multiple anthropogenic canopy gaps.

Based on availability, we randomly selected up to 3 treated stands at each location. We concurrently selected an equal number (up to 3, for a 1:1 pairing with treatment stands) of adjacent reference stands at each location. Reference stands were chosen to be proximate to treated stands. Reference stands were of similar area, hydrology, and vegetative species composition, but without silvicultural disturbance for >12 years (with preference given to older stands). Due to silvicultural treatments that occurred after our surveys in 2013, some stands were unavailable in 2014. Thus, 22 treatment and 24 reference stands were surveyed during 2013 and 2014, but we surveyed 8 new treatment and 6 new reference stands in 2014. Even so, we maintained the 1:1 pairing of treatment and reference stands throughout our surveys.

2.2. Insect surveys

Blacklight traps are a standard technique for sampling nocturnal flying insect assemblages (Covell, 2005; Dodd et al., 2008, 2012a) that effectively attract moths from up to 25 m (Muirhead-Thomson, 1991; White et al., 2016). We surveyed nocturnal flying insects using 10-Watt blacklight bucket traps (Universal Light Trap, BioQuip Products, Gardena, CA, US) powered by 12 V gel-cell batteries (Covell, 2005; Dodd et al., 2008, 2012a). We placed HERCON® Vaportape II insecticide-treated plastic strips (Hercon Environmental, Emigsville, PA, US) inside the traps, and lifted traps 1.5–2.5 m above the ground. Traps were active from 21:00 to 06:45 h (ca. dusk to dawn). We concurrently surveyed treated and reference stands during one randomly selected night with one active trap per stand. We collected samples each following day and froze them for lab analysis. Insect trap locations were collocated with bat acoustic detection devices as part of a concurrent study of the relationships between insect availability and bat activity. Detectors were situated randomly within stands, within canopy gaps, and >50 m from the edge of the stand (Ketzler, 2015), Insect traps were located >200 m from the detectors and >50 m from the edge of the stand.

We analyzed insect biomass collected at each treatment and reference stand. Total arthropod biomass was determined to the nearest 0.01 g. We did not include samples that weighed <0.01 g. In addition to total biomass, we also determined biomass of Lepidoptera (moths), Coleoptera (beetles), and Diptera (flies) because these insect orders are frequent prey for bats (Feldhamer et al., 2009). Because some bat species forage preferentially on larger or smaller insects, we used the methods proposed by Dodd et al., (2008, 2011, 2012b) to sub-divide Lepidopteran biomass based on wingspan into micro-Lepidoptera (<20 mm) or macro-Lepidoptera ($\geq$20 mm). Similarly, we used body length to separate biomass of micro-Coleoptera (<10 mm) and macro-Coleoptera ($\geq$10 mm). All other Orders were combined as other insect biomass (i.e., total biomass-Diptera-Coleoptera-Lepidoptera = other biomass).

2.3. Vegetation surveys

We surveyed forest vegetation within 10 circular, 0.05 ha (12.62-m radius) plots that were located at ~100 m intervals along two 400 m transects per treatment and reference stand based on surveys used for habitat assessments in the Mississippi Alluvial Valley (Wilson et al., 2007b). We started transects at least 50 m from the edge of the stand at a randomly selected access point and traversed each transect on a randomly selected azimuth, with the restriction that transects not exit the surveyed stand. If barriers were encountered (i.e., oxbow lakes), the observer altered the azimuth of the route but continued the survey transect. If transects crossed, the distance between plots was altered to ensure plots did not overlap. With each plot, we measured diameter at breast height (dbh) of all trees $\geq$20 cm dbh to calculate basal area of large trees. We identified each tree to species, and classified tree condition as alive, dead, or downed dead wood. We estimated mean percent canopy closure using a spherical densiometer at 4 points in the cardinal directions along the edge of the 10 circular plot boundaries (Twedt and Somershoe, 2010). We counted stems of