Forest Ecology and Management 320 (2014) 6–12

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Assessing changes in bird communities along gradients of undergrowth deterioration in deer-browsed hardwood forests of western Japan

Shin-Ichi Seki [a,*], Daisuke Fujiki [b], Shigeho Sato [c]

[a] Kansai Research Center, Forestry and Forest Products Research Institute, Nagai-kyutaro 68, Momoyama, Fushimi, Kyoto 612-0855, Japan
[b] Wildlife Management Research Center, 940 Sawano, Aogaki-cho, Tanba, Hyogo 669-3842, Japan
[c] Shikoku Research Center, Forestry and Forest Products Research Institute, Asakura Nishimachi 2-915, Kochi 780-8077, Japan

ARTICLE INFO

Article history:
Received 22 October 2013
Received in revised form 14 February 2014
Accepted 14 February 2014
Available online 15 March 2014

Keywords:
Bird community
Sika deer
Forest deterioration
Shrub-layer decline rank
Spatial spread
Western Japan

ABSTRACT

The impacts of deer browsing on forest ecosystems, including effects on woodland bird species, are now rapidly being felt in western Japan, and quick assessments regarding the spatial and temporal expansion of deer effects are urgently needed in forest management. We gathered multisite profiles of local bird communities together with information on deer-induced changes in forests' physical structure and evaluated deer effects on bird communities by using an ordination approach. Forty-two survey sites were established in mountainous cool–temperate forests in the Mt. Hyonosen region, western Japan. Bird abundance at each site was estimated in June 2012 by using the conventional fixed-radius point count method. Deer-induced changes in forests' physical structure were evaluated by using the shrub-layer decline rank (SDR; ranked D0–D4 based on visual categorization of the shrub-layer vegetation cover). The most recent SDR scores varied from D0 to D4, and by considering previously published scores (5–6 years previously), the intensity of deer effects on vegetation during the intervening period were classified as continuously low at 18 sites, increasing at 11 sites, and high at 13 sites. In the nonmetric multidimensional scaling plot of bird community dissimilarity, sites with lower and higher SDR scores were plotted in a mutually exclusive way. SDR scores explained 11.6% of the among-site differences in bird communities over the effects of various microhabitat differences in a partial canonical correspondence analysis. Another advantage of using SDR scores to assess multisite profiles of local bird communities is that the local indicator species for a forest with a lower impact of deer browsing can be roughly estimated without requiring well-defined control data. In the study region, six potential indicator bird species were identified as being closely associated with low-SDR sites based on an indicator species analysis. SDR-guided management of deer density is being considered in western Japan due to its easy application, even at a regional scale. An SDR-guided management strategy might also be preferable for maintaining local bird communities because it would be possible to infer resulting changes in native bird communities using SDR scores.

1. Introduction

Differences in forests' physical structure often result in differences in bird communities (MacArthur and MacArthur, 1961) because each member species prefers or depends on specific foraging and nesting microhabitats within a stand. Therefore, various natural disturbances, as well as artificial modifications of forest habitats, strongly affect local bird communities (King and DeGraaf, 2000; Seki, 2005; Brown et al., 2011), and woodland bird species are often selected as indicators of forest management practices (Koch et al., 2011; Fuller and Rothery, 2013). Browsing and grazing by herbivorous animals affects forest structure (Fleischner, 1994; Whitehorne et al., 2011), and browsing by overabundant deer has become a major cause of natural disturbance in many regions of the Northern Hemisphere, including Europe (Fuller and Gill, 2001), North America (Rooney and Waller, 2003), and the Japanese Islands in East Asia (Takatsuki, 2009; Yoshikawa et al., 2011). The impacts of deer browsing on forest ecosystems, including the effects on woodland bird species, have been studied extensively in the aforementioned regions for more than two decades (Casey and Hein, 1983; Hino, 2000; Gill and Fuller, 2007; Holt et al., 2011).

* Corresponding author. Tel.: +81 75 611 1201; fax: +81 75 611 1207.
E-mail address: seki@affrc.go.jp (S.-I. Seki).

http://dx.doi.org/10.1016/j.foreco.2014.02.015
0378-1127/

In the Japanese Islands, range expansions and population increases in sika deer *Cervus nippon* occurred during the late 20th century (Takatsuki, 2009). Several hypotheses have been proposed for this sika deer population explosion, such as recent low mortality due to decreases in snowfall and hunting pressure, or increases in food resources after extensive afforestation (Takatsuki, 2009). Sika-deer-induced deterioration in natural forests has been reported since the 1980s, and the problem has spread throughout the four main islands of Japan during the last decade (Fujiki and Takayanagi, 2008; Yoshikawa et al., 2011). Because deer-induced forest deterioration has been spreading rapidly into wide areas and a variety of habitats, related effects on bird communities will also have expanded at a regional scale.

However, we have only fragmented information about effects on bird communities from observations at restricted research sites: either sites with continuous records facilitating temporal comparisons before and after the deer impact (e.g., Wild bird society of Japan Nara branch, 2011), or study plots located close together on either side of a temporal "deer front" (e.g., Seki and Sakanashi, 2012; Okuda et al., 2012) or deer exclosure (including artificial or natural exclosures; e.g., McShea and Rappole, 2000; Allombert et al., 2005; Gill and Fuller, 2007; Holt et al., 2011; Martin et al., 2011) that facilitate spatial comparisons among plots differing only in the level of deer impact. Deer grazing clearly affects forest bird communities, by decreasing the abundance of undergrowth-dependent species (Hino, 2000; McShea and Rappole, 2000; Gill and Fuller, 2007; Holt et al., 2011), increasing the abundance of open-habitat dwellers (Casey and Hein, 1983; Hino, 2006; Okuda et al., 2012), and occasionally increasing the abundance of bark feeders and some stem feeders (Hino, 2006), but it remains unclear how changes in bird communities synchronize with the spatiotemporal deterioration of forest undergrowth. Timely understanding of the increasing impact of deer is especially important for forest management at a regional scale. Common animal species in common vegetation in subject regions are often regarded as being of low conservation concern because of their wide distributions, whereas rare species, such as alpine-habitat specialists, are treated as being of higher conservation priority (e.g. Seki and Sakanashi, 2012). However, in regions that are experiencing a rapidly spreading "deer front," the effects of forest deterioration can strongly affect local populations of some common woodland birds.

The lack of knowledge about the spatial and temporal spread of deer effects in forest ecosystems is partly due to the difficulty in obtaining up-to-date information about the degree of deer-induced habitat changes at a regional scale. In western Japan, the shrub-layer decline rank (SDR) has come to be used as a simple but accurate measure of deer-related declines in the shrub-layer vegetation of deciduous hardwood forests (Fujiki et al., 2010). The SDR can be determined by a labor-saving method based on visual categorization of shrub-layer vegetation cover together with signs of deer browsing, as it has a strong linear relationship with the observation frequency of deer (Kishimoto et al., 2010). Due to its easy application, SDR contour maps have been created and updated in Hyogo Prefecture and some neighboring prefectures (Fujiki, unpublished data).

In the present study, we examined the effects of deer-induced forest deterioration on bird communities in the northwestern part of Hyogo Prefecture. We assessed spatial and temporal changes in forest physical structure using the SDR as an index and extracted associations with among-site differences in bird communities from the effects of other microhabitat differences by using an ordination approach. We also used a species-level analysis (i.e., an indicator species analysis) to identify species associated with certain stages of deer-induced forest deterioration.

2. Materials and methods

2.1. Study area

The study was carried out in an area within 30 km from Mt. Hyonosen (35°35′N, 135°51′E, 1510 m a.s.l.) at the eastern edge of the Chugoku Mountains, western Japan (Fig. 1). Mt. Hyonosen and its surroundings were designated as an Important Bird Area by Birdlife International; the area contains a significant number of biome-restricted species for primary cool–temperate hardwood forests, such as the Siberian blue robin *Luscinia cyane* and grey bunting *Emberiza variabilis* (Wild Bird Society of Japan, 2010). However, primary forest exists as fragments and the remainder of the area is covered with coniferous plantations with some secondary hardwood forest patches among them. Until the early 2000s, the deterioration of natural forests caused by sika deer was restricted to certain areas in the southern part and at lower elevations in this region (Fujiki et al., 2011). However, deer effects have been spreading to the northern and higher altitude regions since the mid-2000s.

2.2. Bird and shrub vegetation survey

Data were collected in June 2012, when breeding activities peak for both resident and migratory species. Forty-two bird survey plots were placed in mountainous cool–temperate hardwood forest patches above 750 m elevation (Fig. 1). All survey points were placed at least 200 m apart and 50 m from a hardwood patch edge,

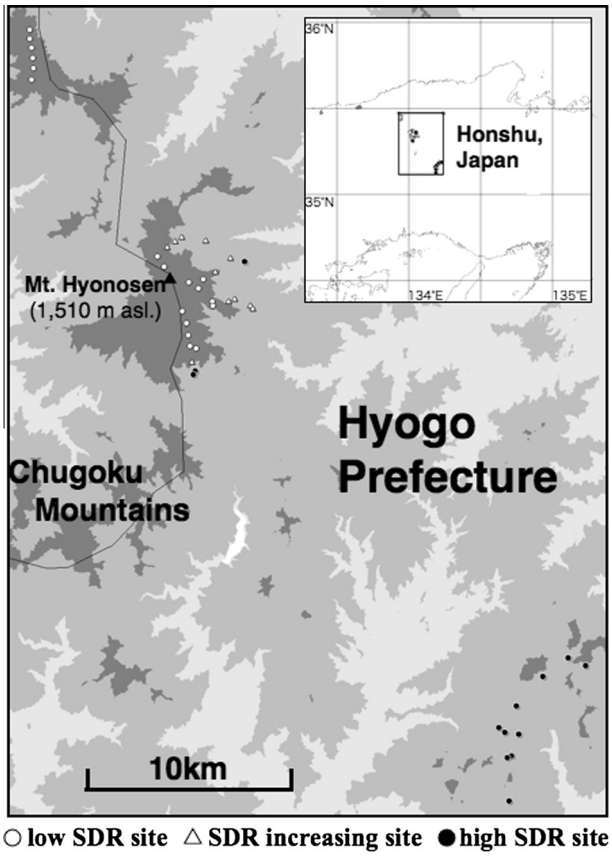

Fig. 1. Location of the study area. The 42 bird survey sites are indicated by three different markers based on the recent history of the shrub-layer decline rank (SDR; see methods for details). The map is shaded by different depths using contour lines at 500-m intervals of elevation as borders.