EFFECTS OF A GYPSY MOTH ERADICATION PROJECT ON NONTARGET ARTHROPOD AND AVIAN COMMUNITIES IN THE OZARK MOUNTAINS OF ARKANSAS (USA).

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ABSTRACT

Recent colonization and establishment of gypsy moth, *Lymantria dispar* (L.), in oak forests of the Ozark Mountains in Arkansas (USA) resulted in aerial sprays in 1994 and 1995 with *Bacillus thuringiensis var. kurstaki* to eradicate the infestation. Concern that reduction in lepidopteran larvae would negatively influence the breeding success of the Neotropical migratory bird species that nest in these forests resulted in research to assess effects of eradication on arthropod and bird communities. Sampling of oak foliage in tree canopies in control and spray plots was conducted to estimate abundance and biomass of nontarget forest canopy arthropods in 1994, 1995 and 1996. Coincident with arthropod sampling, bird censusing at fixed-radius plots was conducted along transects in all spray and control plots to assess abundance and diversity of the bird community. The eradication sprays, in separate plots in spring of 1994 and 1995, dramatically reduced lepidopteran larval populations for four to six weeks post treatment. Lepidopteran populations remained low during the same time period one year post treatment, but appeared to be recovering by year two. The effect of spraying on the Neotropical migratory birds was evident in only a few species that were specialists on lepidopteran larvae. Reproductive success of Hooded Warblers (*Wilsonia citrina*) seemed little affected by reduction of larvae, suggesting that Neotropical migratory birds may be adapted to fluctuations in prey availability on their breeding grounds.

INTRODUCTION

Since its introduction into Massachusetts in 1869, gypsy moth, *Lymantria dispar* (L.), has become a serious forest pest in the northeastern United States. Although the
range of this insect is expanding slowly both south and west, many susceptible forest areas of the U.S. are not yet infested (Liebhold et al. 1997). Infestations that do occur in uninfested regions are primarily the result of accidental transport of egg masses from infested regions. Widespread pheromone trapping in uninfested areas and “high-risk” locations is conducted to detect male moths. When isolated infestations are detected, attempts at eradication are made if the threat of successful establishment and potential for future outbreaks are confirmed. The Ozark Mountains in the states of Missouri and Arkansas contain a high proportion of oaks (Quercus spp.), a favored host plant for gypsy moth, and are considered an extremely high-risk area in regard to successful colonization, establishment and defoliation from gypsy moth (Liebhold et al. 1997).

In 1992 a gypsy moth infestation that appeared to have started about eight years earlier was detected in northwestern Arkansas. At the time of discovery it was considered to be an extremely rapidly reproducing population with egg mass numbers estimated to be several thousand per ha. USDA Forest Service, APHIS (Animal and Plant Health Inspection Service), Arkansas Forestry Commission, Arkansas State Plant Board, and National Park Service expertise, in conjunction with public involvement, was instrumental in determining eradication protocol for the outbreak. Preliminary egg mass surveys suggested that fewer than 240 ha were infested, and in spring, 1993, eradication efforts were initiated using the insect growth regulator, Dimilin (diflubenzuron). Pheromone trapping, to both evaluate treatment effectiveness and to establish more accurately the extent of the infestation, was conducted in summer 1993. Results of trapping suggested that although pesticide treatment had been effective, populations of gypsy moth were more widely distributed than originally believed and therefore the spray area had not been adequately defined. The belief continued that eradication could be achieved, and aerial spraying with Bacillus thuringiensis var. kurstaki (Btk) was combined with intensive and extensive pheromone trapping within and surrounding the infestation areas in 1994 and 1995.

Concern about either the impact of continued gypsy moth infestation growth, or, alternatively, the impact of eradication methods on nontarget organisms had been prevalent since the discovery of this infestation. The infestation area was adjacent to the Buffalo National River, a high-use recreation area that was the first “National River” in the United States National Park System. Several endangered plant and animal species occurred in the spray area, and the Ozark Mountains are breeding grounds for a wide variety of Neotropical migratory birds. There has been anxiety that populations of birds that breed in forests of eastern North America, particularly Neotropical migratory warblers, may be declining (Robbins et al. 1989, Terborgh 1989, Finch 1991). The relatively unfragmented interior highlands of the Ozark Mountains may represent significant population sources, where reproductive success is still high among Neotropical migratory bird species (Robinson et al. 1995).
Reproductive success and survival of passerine birds may be limited by food (see review by Martin 1987); however, few studies have actually examined the relationship between food abundance and bird population dynamics during breeding seasons. Cooper et al. (1990) found that spraying diflubenzuron in deciduous forests in West Virginia did not affect bird community structure, but individual species did change foraging behaviors and types of arthropods that they ate in sprayed areas compared to non-sprayed forests (Sample et al. 1993). Rodenhouse and Holmes (1992) found that Btk reduced the number of nesting attempts by Black-throated Blue Warblers (Dendroica caerulescens) in New Hampshire. Reduction in both abundance and species richness of nontarget Lepidoptera has been documented in Bt sprayed plots (Reardon et al. 1994). Most warblers specialize on Lepidoptera larvae during the breeding season, feeding their nestlings caterpillars gleaned from the forest canopy (Morse 1989). We hypothesized that the reduction in caterpillars in the areas sprayed with Btk would potentially reduce the overall breeding success of the caterpillar-eating birds.

The primary objectives of our research were to examine the effects of the Arkansas Btk spray program on: 1.) abundance and biomass of nontarget forest canopy arthropods, and 2.) structure of the Neotropical migratory bird community that nests in the Ozarks during the breeding season.

MATERIALS and METHODS

Aerial Btk sprays

Aerial spraying with Btk was conducted when gypsy moth egg hatch was expected to be complete and larvae were first to second instar (late April to early May). Two applications, approximately a week apart, were made on 10,150 ha in 1994 and on 7,150 ha in 1995. Areas sprayed in 1995 were adjacent to but distinct from the area sprayed in 1994. Sprays were applied by helicopter and fixed wing aircraft in 1994, and by fixed wing aircraft in 1995. In 1996 no spraying was conducted, because exceptionally low numbers of gypsy moth males were caught in the previous summer’s pheromone traps.

Canopy Arthropod Sampling Plots

In 1994 four study plots were selected prior to spraying: two in the 1994 Btk spray area and two control plots. In 1995, two additional plots were selected in the 1995 Btk spray area, and the same four 1994 spray and control plots were also utilized. In 1996, all six plots that had been sampled in previous years were again sampled.

Twenty oak trees (separated as to red oak and white oak) were selected and flagged in each study plot. A pre-spray foliage collection was made in each year, and additional foliage collections were made at weekly intervals thereafter through June. Final collections were made in July.
Each sample unit consisted of three terminal branches cut from one of the trees with an extension pole pruner and caught in an attached plastic bag. Branch cuttings were standardized as much as possible in order to obtain similar amounts of foliage from each tree. All foliage was pruned of wood stem material and immediately placed into a paper bag (ca. 30 x 17 x 30 cm), which was folded over and stapled closed. Bags were returned to the laboratory and frozen overnight to kill all arthropods. The next day each bag was weighed, the contents removed and the bag weighed again to determine wet weight of foliage biomass. The foliage was shaken and all stem and leaf surfaces were carefully examined to ensure collection of all arthropods. Total arthropod wet weight was measured and specimens were held for identification in 70% ethyl alcohol. Lepidoptera larvae were counted and classified to size: small (~<6 mm), medium (~6 and <19 mm), or large (~≥19 mm). The foliage was dried and subsequently weighed.

**Bird censusing:**

Six transects of varying length were established at the six canopy arthropod study sites. Lengths of the transects were constrained by availability of continuous suitable forest. As nearly as possible, fixed-radius census points (Hutto et al. 1986) were established at 150 m intervals along the transects.

Beginning in early May 1994, and continuing in 1995 and 1996, these four to six areas were censused once each week during non-rainy days for four weeks, the last census being conducted in early June of each year. The censuses began at sunrise. All birds heard or seen within a 50 m radius of the census point within a 10-minute period were recorded. Results presented here are expressed in terms of mean number of individuals per census point for spray and control areas.

**RESULTS and DISCUSSION**

In both 1994 and 1995 mean numbers of immature Lepidoptera per kg dry foliage present in current year’s Btk spray plots and control plots were similar prior to spraying. Abundance of caterpillars in sprayed plots dropped precipitously following Btk application, and remained lower for several weeks. By mid-July, mean numbers of caterpillars in sprayed plots were similar to numbers in control plots (Lih et al. 1995). Resurgence in immature Lepidoptera numbers in sprayed plots probably represents different species than were present at time of spraying. There was also relatively low abundance of caterpillars throughout May and into June 1995 on plots that had been sprayed in May 1994, and throughout May and into June 1996 on plots that had been sprayed in May 1995. This suggests that although recovery may have begun, full recovery of early season Lepidoptera did not occur within the first year following spraying but appeared to be approaching normal levels by the second year after spraying.

Of the 58 species observed during censuses conducted during the breeding seasons of 1994, 1995, and 1996, 9 species showed significant differences between years or
between spray and control plots. The most striking was Yellow-billed Cuckoo (*Coccyzus americanus*), which specializes on large arthropods and is a late breeder in the Ozarks. Cuckoos were not present in sprayed plots in 1994. They did not reappear on those plots in 1995, but returned during the 1996 breeding season. Cuckoos were present in very low numbers on plots sprayed in 1995 and not present at all during the 1996 breeding season on those plots.

Four species had significant year effects, meaning that their numbers fluctuated among years independent of treatment. Three of these, Carolina Chickadee (*Parus carolinensis*), Blue-gray Gnatcatcher (*Polioptila caerulea*) and Red-eyed Vireo (*Vireo olivaceus*), are known to consume caterpillars during the breeding season. (The fourth species, *Ruby-throated* Hummingbird (*Archilochus colubris*), is a nectivore.)

Four species had significant treatment effects, meaning that their numbers fluctuated among treatments independently of year. The most striking of those is Scarlet Tanager (*Piranga olivacea*). It is a caterpillar specialist in the Ozark forests and its numbers were greatly reduced on both spray areas compared to the controls.

Nagy and Smith (1997) examined the effects of the spraying in 1994 on the reproductive success of Hooded Warblers (*Wilsonia china*), a Neotropical migratory species that is a common shrub nester in the Ozarks and eats caterpillars. Data were collected in 1994 and 1995. Nesting success, defined as at least one young fledged, was higher in controls than in 1994 sprayed areas. Day 5 nestling masses showed an increase in mass over the duration of the breeding season in the spray zone, while nestlings in the controls maintained the same day 5 mass throughout the duration of the breeding season.

Results of censuses and the study of Nagy and Smith (1997) suggest that some bird species that are caterpillar specialists were affected by spraying, such that their numbers were reduced on sprayed plots. However, the effect appears to be transitory, with birds beginning to return two years after application of Btk. Overall, reduction of lepidopteran larvae due to Btk applications appeared to have minimal impacts on reproductive success of Hooded Warblers, either in the year of Btk application or the year following Btk application. Possibly long-distance Neotropical migratory birds are adapted to deal with annual fluctuations in arthropod abundance and are capable of breeding during periods of low caterpillar abundance. It is also possible that application of Btk did not reduce caterpillar abundance below a critical threshold necessary for breeding by Hooded-Warblers (Nagy and Smith 1997).

**LITERATURE CITED:**


